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SCIENCE FIGHTS DEATH

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INTRODUCTION

IT is well worth asking ourselves what should be our attitude towards disease. We may regard it as inevitable and to be accepted as something which mankind must always suffer; we may take a morbid interest in it, as many do, shuddering, but at the same time enjoying, stories of all the horrible things that can happen to us. The writer would suggest, however, that the correct attitude is one in which, while recognizing that the human body is liable to many different and often dangerous diseases, these have to be studied and ways found not only of treating them, but of preventing them.

This is what scientific medicine of to-day is doing, and in the following pages something of the story of what science has done against disease is told. There can be no question that we are still largely preoccupied with the treatment of disease; but everyone realizes that medical science of the future will aim at the elimination of as many forms of disease as possible. To achieve this continuous study is necessary, and the lay public can do much to help. They can do so by learning something of the causes of disease, by supporting medical research, and by encouraging earlier and better treatment by paying attention and seeking advice about even the most trivial illnesses. The writer has no doubt that the medical service of the future will enable this to be done, and will provide a service in which all the newest discoveries of science will be rapidly and freely available to the whole community.

CHAPTER I

THE PROBLEM

DISEASE and death probably play a greater part in the life both of the individual and of the community than any other of the problems with which mankind is concerned. Death is inevitable; but, despite that, man has always made endeavours to find a way by which death can be defeated, and, as we shall see, considerable success has been attained in postponing that inevitability. The death from which none can escape should come at the end of long and healthy life; but this prospect is always endangered by disease. By this term we mean any departure from the normal healthy state, whether inherited or acquired. The greater number of diseases are acquired, and many attack the human body from outside. A number of diseases are trivial and cause only a temporary departure from normal, but many are very dangerous both to health and to life.

To a very great extent the success that has been achieved in postponing death has resulted from the discovery that certain previously fatal diseases can be treated and prevented. It can now be claimed that, while ultimate death remains as inevitable as it has been throughout the whole of man's history, the extent to which it is caused by avoidable disease becomes less and less. Of the changes to which the world may look forward with considerable confidence an increase in the length of life and freedom from the more serious of the deadly diseases are among the most certain.

LIFE ALREADY PROLONGED

We need not quote the now well-known figures of the increase in the " expectation of life " that has occurred during this century. It is by means of these figures, calculated from the ages at which the population is dying, that, for example, insurance companies estimate the probable date of death for those of particular ages. The increased expectation of life to-day in civilized countries is very definite and quite considerable.

We propose in this book to describe not only the steps that science has taken in the fight against death, but also, by a description of certain of those diseases, to show what may be expected in the future. We must concern ourselves with the chief diseases and with the principal causes of disease. Everyone realizes that many so-called minor ailments may be the beginning of very serious complaints, and we shall not have space to look at that aspect of disease very closely. It is, however, one on which medical science must concentrate more and more, for when the great classes of infectious, parasitic, and cancerous diseases have been finally conquered there may still be a large amount of human suffering from comparatively small defects which at the moment are very often neglected.

MINOR ILLNESSES OFTEN IMPORTANT

It is not generally realized that many of these minor ailments may be of great diagnostic importance in pointing to the beginning of changes which might prove serious or even fatal. In this connection we shall later touch on the importance of rheumatism, so often completely neglected in the very early stages at which, even with our present knowledge, something of lasting benefit could be done. The lay public as well as the medical profession have a certain responsibility in this matter, for most people try to disregard trivial illnesses and fail to take advice about them. The dangerous delay that may occur from this is one which cannot be too strongly emphasized.

DISEASE AN AGE-LONG PHENOMENON

It is as well, before going on to consider the present-day position of medicine, to remember that while a large number of diseases have been definitely recognized only in quite recent times, and while there is a little evidence that we may actually be dealing to-day with entirely new diseases, in the main we are suffering from the same diseases as those which afflicted even our earliest ancestors. We shall see that modern conditions have produced diseases directly associated with or caused by industry, of which there is no exact counterpart even in historical times; but at the same time modern civilization has removed many of the hazards, particularly accidental, to which mankind was subject in earlier ages.

We must also consider whether disease is likely to affect mankind in the world of the future as it undoubtedly has in the past. A close study of history reveals that in many instances disease has had even greater effects on world history than all the intrigues of ambassadors and the bravery of soldiers. There have been occasions, indeed, on which but for the intervention of a deadly epidemic disease, such as typhus fever, the whole history of the civilized world might have been changed. In prehistoric days it is probable that many of the great disasters that have occurred to quite highly developed civilizations, as revealed by the work of archæologists, were due to the decimation of populations by disease as much as by natural catastrophes. We shall see that this is a danger not entirely removed from even the most highly civilized races, and possible even to-day among those sections of mankind which are still comparatively primitive.

DANGER OF UNSCIENTIFIC METHODS

We must not forget in any discussion of disease that the attitude of man towards it, and his beliefs with regard to the construction and functioning of his own body, are of considerable importance. It cannot be assumed that a knowledge of what is normal in the human body means that the individual will maintain his body in perfect health; but it is quite certain that a complete ignorance of the elements of simple anatomy and physiology lay the individual open to all kinds of beliefs which may actually foster disease, or at least make him an easy victim for those charlatans who are always ready to exploit man's fear of death. Throughout all ages there have always been in opposition to the scientific study of the human body, and in opposition to the system of medicine based on that study, a large number of unorthodox and usually unscientific theories as to the function of the various organs of the body and of the causes of disease.

The recognition of the true causes of disease depended both on the advancement of general scientific knowledge and on the accumulation of facts about the structure and function of the human body. So long as the working of the body was a matter for conjecture, so long were theories about disease likely to be false. It was not, for example, until after Harvey's discovery of the action of the heart in circulating the blood throughout the body that any true conception of diseases of the heart was possible. We do not yet possess anything like a complete knowledge of every process that goes on in the human body, but at least we know enough about its detailed structure to be able to demonstrate and to identify disease processes. We are therefore in many instances able to claim that we possess scientific proof of how disease occurs and how it acts.

It is impossible to elaborate this to any extent, but we must make one point clear. In the pseudo-scientific theories of disease that are presented to the general public it is usually claimed that the individuals or group who have elaborated the theory have discovered *the* cause of all disease. This is typical of the modern osteopathic and chiropractic theories in which all diseases are said to be caused by one change in the human anatomy.

A SINGLE CAUSE OF ALL DISEASE IMPOSSIBLE

Scientific medicine has shown that this idea of a single cause for all disease will not bear even the most superficial investigation. The human body is composed of uncountable millions of cells varying in size, shape, and relation to each other, even in fundamental chemical construction, and very widely in function. Variations in these—and from the large number of variabilities present even in the average normal the possible variations are of enormous dimensions—may and do cause changes in the body amounting to disease. In addition, however, it has been shown that this combination of diverse units which we call the human body is subject to many outside influences and is capable of almost innumerable different responses to these.

CAUSES OF DISEASE

These outside forces vary from the ordinary environment to attacks by chemical, physical, and living agents potentially dangerous either to a special group of cells within the human body or to the body as a whole. The diseases caused by these agents can be classified and grouped, and, speaking in very broad terms, the causes of diseases are not very numerous. When, however, we investigate these larger groups we find that within them are an almost endless number of agents each of which, while the disease it causes may have the general characters of the group into which it falls, nevertheless produces a condition of the body which is so definite as to be clearly recognizable as a separate entity. Once again, when we consider the ways in which all these agents may attack the separate organs of the body, and when we consider the changes they may cause, we find that the causes of death from disease run into many hundreds.

We have raised this question of the unscientific foundation of these non-medical theories of disease in order to emphasize at the start that if the world of the future is to be rendered free from the more dangerous diseases dependence must be placed on orthodox medical science. It is not suggested for one minute that medical science has reached anything like finality in its search for knowledge. On the contrary, it is probably true to say, and particularly in certain fields which we shall discuss in Chapter IV, that we are only beginning to accumulate knowledge that will enable us to solve many problems of great importance. Nor is it suggested that the exponents of medical science are all sufficiently well grounded in it to be efficient in the fight against disease; for it must be agreed that under present-day conditions a large number of ordinary doctors are in a position neither to make use of the knowledge which they have nor to keep pace with all modern developments. Still less is it suggested that the organization of the medical profession has reached its optimum efficiency ; for, while it will be generally admitted that the medical profession in this country manages to give a remarkably high degree of skill to its individual patients, as a whole the work is unorganized, and the arrangements permit at one and the same time of much overlapping and of many gaps in the service.

It is also worth remembering that the knowledge gained by medical science has not been gained as the result of a definite, co-ordinated plan ; it has resulted from the work of innumerable and very often forgotten workers. It has received very little encouragement and help from the community or the State. Professor H. Levy has summarized the position very well when he says that " these scientists struggle along begging for grants towards the cost of apparatus and publications, and in the past help has been given grudgingly as a luxury which the community could ill afford." Despite these conditions, worker after worker has striven not only to discover the fundamental causes of disease, but also to devise methods by which they could be successfully treated or completely prevented. It is with a description of these discoveries that we are concerned in the following chapters, and by showing something of what has been achieved we hope to be in a position at the end of the book to consider what further advances can be made, and what their effect will be on the men and women of the future.

CHAPTER II

BACTERIAL DISEASE

THE development of medical science has been a long and very slow process, and for the greater part of man's history he had only the vaguest conception of the causes of disease. So long as knowledge of the human body remained imperfect it was possible for theories as to the cause of disease to be held which, now that the structure of the human body has been understood, we recognize as quite untenable. Even when the physical basis of the body became clear there was a long period before any definite idea was formed of how the different organs functioned. This permitted a further set of theories of the causation of disease which only modern scientific work has proved to be without foundation. It is still possible for people who have only an elementary knowledge of human anatomy and physiology to hold strange and primitive theories of the cause of human ill-health. Since this century began there has been a comparatively rapid accumulation of real knowledge of the cause of disease, and there has been elaborated a variety of techniques by which the causative agents can be discovered and demonstrated.

DISEASE MAY BE DUE TO OUTSIDE AGENTS

Even in quite primitive communities there has usually been some kind of belief that certain diseases were caused by agents acting on the human body from outside. This idea was frequently linked with religious and other beliefs, and we now recognize most of them as having been mere superstitions. In actual fact a very large proportion of human disease is caused by agents which attack the body from outside, and the first class of these which we wish to consider are the pathogenic bacteria. Bacteria are the smallest existing living things, and, while they have been recognized for over two hundred years, it is only in the last seventy years that their importance to the human body has become clear. Pasteur, a great Frenchman, began this work, which has been carried on at increasing speed by a large number of observers. The work that these scientists have done constitutes the proof that germs do cause disease, and it is no longer necessary to speak of the "germ theory of disease," as was once done, because this has now been demonstrated as scientifically correct so many times by so many observers and in so many different countries

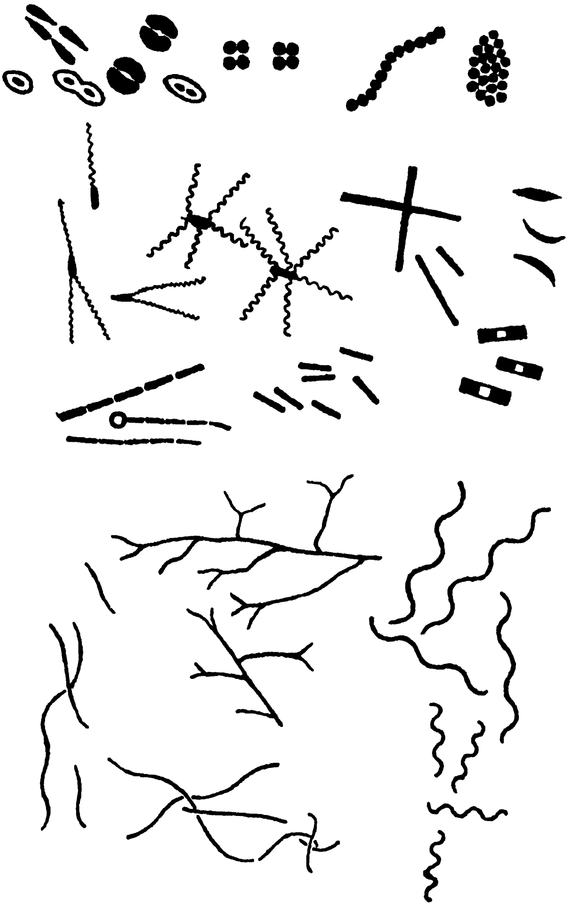

FIG. 1.—BACTERIA OF VARIOUS TYPES.

that it stands as one of the incontestable facts of modern science.

WHAT GERMS ARE

Bacteria are so small that it is only with the development of other modern sciences that man has been able to recognize their existence. The chief instrument which has made this recognition possible is the microscope, by the magnifying power of which these minute creatures are rendered visible. While germs are invisible individually, in bulk they can be seen when grown artificially outside the human body, and they fulfil all the conditions of living organisms—growing, multiplying, and using up foodstuffs. They consist of tiny particles of living protoplasm, and when studied chemically are found to require to a very considerable extent the same type of chemical substance as is used by all other living creatures for food. Their actions, when they are grown artificially in the laboratory, can be clearly followed, and by a study of their mode of living, their size, and their shape it is possible to classify and identify them.

There are, of course, a very large number of microbes which do not interfere with man in any way, and there are a few which are definitely useful. Man depends, to some extent, on those strange germs which live in the soil and by co-operation with certain plants remove nitrogen from the air and make it available for plants which man uses for food. Other germs play their part in industrial processes, and man makes use of others in dealing with the sewage of large towns. There are a large number which live in and in close contact with man and which do not appear to play any important part in his life at all. This is, of course, a recognized phenomenon, widespread in nature, by which one type of living creature exists as a saprophyte on the other.

THE RECOGNITION OF BACTERIAL DISEASE

Before going on to describe the action of certain typical bacteria, it is as well to consider briefly how we shall judge whether they are causing disease or not. From what we shall say in other chapters it will become obvious that there are many possible causes of disease and abnormality in the human body, and in any disease there is always apt to be a combination of more than one of these possible factors. In true bacterial disease it should be possible to demonstrate that the causative germ is always present in the diseased tissues. To complete the proof we must also be able to maintain that germ outside the body, and to show that when it is introduced alone and free from all other possible sources of trouble into another human or animal body it will reproduce the disease.

A further proof may be given if we can show that in the course of recovery from disease the body produces in the circulating blood a substance or substances which have a definitely harmful or even lethal effect on the germs. This form of proof may be further emphasized if it is possible to take the blood thus shown to contain substances antagonistic to the germ and to use it for the treatment of cases of the disease.

There are certain difficulties in obtaining all these proofs in every disease. It must be remembered that many of these germs are so small that twenty to thirty thousand of them placed together will measure only one inch, and that they are for the most part colourless. Unless a method is available by which they can be coloured, as by a dyeing process, they may not be visible even under the most powerful of modern microscopes giving a magnification of two thousand times or more. When this difficulty has been overcome we may find that the germs, while they grow freely inside the human body, prove very difficult to cultivate artificially. We have at our command in the modern laboratory a large number of artificial culture media, as they are called, composed of meat juices, blood, gelatine, egg, potato, and so on, in which many germs grow with the greatest of ease. There are some, however, which require very special conditions, not only as to the foodstuffs offered to them, but also as to the amount of oxygen which they will stand, and the optimum conditions of temperature and moistness. There are still a few germs visible under the microscope which prove beyond the powers of any culture technique known to-day.

We do not seem able to provide certain germs with anything like the conditions which they find in the human body. We may, for example, feel perfectly certain that a particular germ causes ill-health by producing a poison which passes into the patient's system, yet be unable to persuade the germ to do this outside the body. Sometimes it can be done by an elaborate technique, but at a rate which does not compare with the production in an actual case of the disease.

The third proof may be particularly difficult, for many diseases are too dangerous to test out on man himself, while the susceptibility of animals to disease varies greatly. Certain animals have been shown to be particularly susceptible to one disease while almost entirely immune from another. Failure to convey the disease to the test animal does not therefore mean that the germ is not the cause of the disease, but may mean that the particular animal tested is completely immune.

IMMUNITY IS DUE TO ANTIBODIES

There are, even with these gaps in our technique, a sufficient number of diseases in which all the tests can be applied to enable us to prove beyond doubt that the cause of each of these diseases is a particular recognizable germ. From a study of the proven case it is possible to deduce that other diseases in which all the evidence is not so easy to collect must also be due to bacteria. There are, for example, diseases in which the germ has not been, probably cannot be, isolated by the usual methods, but in which the blood of cases recovering from the disease contains substances which protect against it.

The production of antibodies in the blood of animals that have been infected with and recovered from a particular bacterial disease is, of course, of importance from the treatment point of view. The type of antibody which is produced depends on how the germ acts on the human body. It is necessary to distinguish between those germs which produce their chief effect by the destruction they cause to the tissues at the point where they are actually growing, and those which cause disease by producing outside their bodies a poison which can penetrate into every part of the body. In the case of those germs which kill or cause disease by their actual presence within the tissues, the blood tends to produce antibodies which have the power of killing or at least hindering the growth of the germs. In the case of those which produce a poison or toxin the antibody which appears in the blood is an antitoxic substance which acts by neutralizing the toxin.

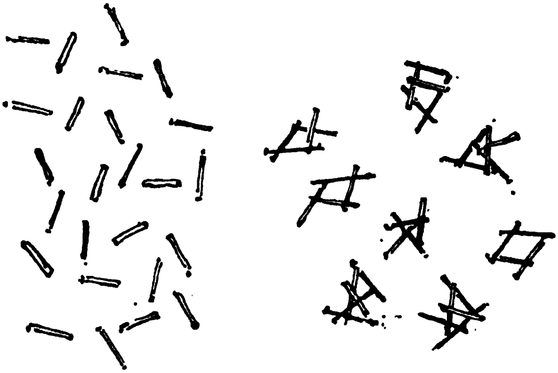

FIG. 2.—AGGLUTINATION AS SEEN UNDER THE MICROSCOPE. The effect of the Antibodies is to make the Bacilli adhere together as on the right-hand side of the figure.

DEMONSTRATING ANTIBODIES

These effects can be shown quite clearly in the laboratory, and a really amazing number of differing antibodies have been shown to exist. One of the commonest is an antibody which causes agglutination of the disease germs whenever it comes in contact with them. To demonstrate this an emulsion of the germ is made and mixed with the blood, suitably diluted, and if these antibodies are present the germs begin to adhere together and form clumps which may actually be visible with the naked eye, or demonstrable under the microscope. This phenomenon has an important place in the diagnosis of obscure feverish diseases, for it occurs in particular with germs belonging to the typhoid group.

The method of demonstrating antitoxic substances will depend on the type of toxin which is produced. A very common type is one which destroys the red cells of the blood, causing the hæmoglobin in them to be released. If a toxin of this type, called a hæmolysin, is mixed with an opaque emulsion of red cells, after a little time the fluid will be found to be quite clear and uniformly red. This again provides the basis for many laboratory tests, for if a patient's serum is mixed with a known hæmolysin and then the red cells are added, the breaking down of the red cells will occur only if the antibody has not neutralized the toxin.

This test has had many developments, and one of the latest is its use in showing that a very common germ which infects many people produces such a toxin. This germ, the Staphylococcus, is the cause of such common conditions as boils and carbuncles, and it acts to a very large extent by destroying the skin at the site where it is growing. Nearly everyone knows how quite a small boil may cause considerable pain, and after it has gone leave a scar where the skin has been destroyed. All this is caused by the Staphylococcus getting into the skin and multiplying at a rapid rate. In addition, however, it produces a hæmolytic poison, and it can be shown that under certain conditions the blood contains antibodies which neutralize this toxin completely. The tissues can indeed be stimulated to produce these antibodies in large amounts, as we shall describe a little later.

SELECTIVE ACTION OF GERMS

It is interesting to discover that many germs have a highly selective action; these are to be found infecting only one part of the body. The Staphylococcus, as we have just noted, is especially common in skin conditions, but it may occasionally affect other parts of the body, particularly the bones. The Meningococcus, on the other hand, is very rarely found causing disease outside the brain. It usually produces a particular type of meningitis which is very often fatal, and, while it undoubtedly spreads throughout the whole body at times, it is in the brain that it causes the chief damage. On the other hand, the Gonococcus, which in many ways strongly resembles the Meningococcus, is almost entirely confined to the urinary tract, the only other site in which it is common being the eye. The Diphtheria Bacillus, as everyone knows, is to be found in the nose and throat, but almost never in any other situation.

This selective action of bacteria provides one of the great difficulties in treatment. If all germs infected the one part of the body in the same way, it might be possible to produce a single antiseptic chemical substance which would deal with them effectively. As it is, they occur in such varying situations—some of which, like the brain, are very difficult to reach—and produce their ill effects in such a variety of ways that no one form of treatment yet devised is effective against them all. We do possess a very large number of chemical substances which we know can destroy most of these germs, but the main difficulty is to find a substance which will do this without injuring the body.

WAYS OF FIGHTING GERMS

The ideal, as already mentioned, would be to find one single substance which would act against them all; but most people believe that the probability is that for each germ a substance may be found having a selective action against it sufficiently destructive to be of value in treatment. It is certainly a very interesting point that despite the minute size of germs they have such individual characteristics that, while one type may be readily destroyed even by traces of certain antiseptics, others may be able to flourish and indeed be encouraged by the presence of the same chemicals.

In the fight against bacterial disease, either in the form of prevention or of treatment, most emphasis has been laid on methods that employ or help the human body to produce antibodies. The most effective use of these substances, as will be readily understood, is against those germs producing toxins which circulate in the blood-stream. If we visualize, to take Diphtheria as the example, the throwing-out of given amounts of poison by the germs present in the throat, we can say that if only we could put into the blood-stream the right amount of neutralizing antitoxin then the diphtheria poison would be of no importance. Once a patient has the disease this can be done only by putting into the blood-stream antibodies derived from another animal.

It has been clearly shown that if small quantities of diphtheria toxin are injected into most animals the blood fairly quickly becomes filled with antibodies. If the blood is withdrawn it can be concentrated in such a way that these antibodies are obtained in quite large amounts. They can then be administered to the patient either by putting them straight into the blood-stream or into some other part of the body from which the blood will take them up, and those who have had the most experience in treating this disease know that its effect can often be dramatic and in a very large number of cases completely effective.

DISEASE PREVENTION

The ideal method of dealing with Diphtheria, however, is that of providing in the blood of potential sufferers amounts of antibodies to the diphtheria poison to neutralize any that may enter the body. In this way the body is able to resist the attack and prevent the disease developing. The same method is used as in producing antibodies in other animals—namely, the injection of a few doses of the diphtheria poison. It is modified in one of a number of ways so that it does not harm the body while it can still stimulate the blood. This process of Diphtheria immunization has now been carried out in this country and others in many hundreds of thousands of cases, and, while no one claims that it gives one hundred per cent. protection to the community, or even to those who have been so treated, it is almost true to say that it gives effective protection to every child who is immunized. That statement must be modified by adding that it is effective only in those children who have been shown to have produced the antibodies in their blood. This is done by the very simple Schick test.

In this test a very small but accurately measured amount of the Diphtheria toxin is injected into the skin of the forearm. The skin is examined a week later, and if the child is susceptible to Diphtheria the skin will show an area of redness. On the other hand, if the child is immune, either from a previous recognized attack or from a mild and unnoticed infection, the skin will show nothing abnormal. It is most interesting if one carries out this test on a large family to find, if there has once been a case of Diphtheria in the family, all those children who were then in contact are immune, while those born after that time, and who therefore have probably not been in contact with a case, are susceptible. It is found, by other tests, that the degree to which the Schick test is positive is closely related to the amount of antibodies in the blood.

ANOTHER TOXIN-PRODUCER

The latest development along these lines is in connection with the germ called the Staphylococcus, which we have already mentioned. It has been shown that this germ produces a poison which can be prepared in such a way that it can be used in treatment, and also that large amounts of antibodies to the poison can be produced in the blood of human beings and animals who are injected with the modified toxin. The work on this subject is a very good illustration of the international nature of bacteriological research. Preliminary observations about this toxin were made many years ago, but it was only after 1928 that the work really began to develop. The first important observations were made in Australia, rapidly taken up in Canada and in Great Britain, and finally confirmed in almost every country in Europe.

At one time, when a new bacterial toxin or antibody was discovered and experimented with in different countries, the workers publishing the results usually described the substances in purely arbitrary terms which they themselves had invented. For many years, however, an attempt has been made to get all the countries to adopt for such biological substances standards and terms which could be comparable everywhere. In late years this work has been much accelerated through the League of Nations, which has set up an International Committee to discuss and fix these standards. Thus, in the case of the Staphylococcus, as soon as it was realized that its toxin in modified form and the antitoxin could be used for the treatment of human beings, steps were at once taken to see that all those countries who have accepted the

League of Nations' authority to set up the standards would refer to these new substances in one and the same way. A standard was proposed and sent to workers in many countries, and, when it was shown that the standard remained stable and the method of testing it was one that could be done by any competent bacteriologist, the standard and its description were officially settled.

SCIENCE IS INTERNATIONAL

The importance of this aspect of bacteriology cannot be too strongly stressed. It is not only that in it there lies an obvious lesson in international co-operation, but it is in itself a very important point in establishing modern medicine on a scientific basis. Biological substances can seldom be assayed in the same way as pure chemicals, and, unless an arbitrary standard is set up and agreed to, doctors and patients would have no guarantee that the substances being used for treatment were up to full strength or even that they had any potency at all. The standards set up are always linked with methods of testing and with safeguards of such a nature that, no matter where one is, one can always be sure that products prepared in accordance with these regulations will produce the maximum effect.

We have already suggested that one dream of the scientist is to find the particular substance which will have a maximum lethal effect on germs combined with the minimum of harmful effect towards the human body. This conception is linked with the name of the great German chemist Ehrlich, and to him we owe the discovery of one group of chemicals which answer this ideal. Ehrlich found, after laboriously testing hundreds of substances, that the chemical arsenic could be combined in such a form with other substances as to produce a combination which has practically no harmful effect on normal tissues, but which destroys the germ which causes Syphilis.

This germ, Spirochæta Pallida, is one of the most dangerous of all those that attack the human body. It not only produces damage to the tissues at the point where it enters the body, but it quickly spreads to every organ and continues to live in the body for many years, producing dangerous and usually fatal disease of many varieties. It also has the very dangerous faculty that it can pass from the mother to the unborn child, in whom it causes death or disease. The discovery that arsenical preparations of the type first made by Ehrlich could kill this germ even when it was buried in the depths of the brain and other organs has made this germ less formidable than it once was.

PERFECT ANTISEPTIC STILL TO BE FOUND

Unfortunately, despite the painstaking work of many chemists, compounds having the same effect on other germs have not been easily found. This work is going on unceasingly, and the probability is that further similar discoveries will be made. Considerable interest was shown some years ago in the metal gold which, it was claimed, could be produced in such form that it would destroy the Tubercle Bacillus. This microbe is, of course, the cause of Tuberculosis in its many forms. The germ has certain peculiarities which separate it from practically all other bacteria. It does not, for example, stain with the same dyes that are used for other bacilli, and it does not grow on the ordinary culture media used in the laboratory. When it is grown, on special foodstuffs, it grows very, very slowly. In the human body, however, it may sometimes spread with amazing rapidity, and all attempts at defeating it on these occasions have proved in vain. The discovery that organic combinations of gold had some effect on the Tubercle Bacillus raised hopes that at last it would be conquered; but it is now realized that, while some successes may be obtained, this precious metal cannot be considered specific against the disease.

Quite recently hope has been raised that a new chemical compound has been found that will enable us to deal effectively with another dangerous germ, the Streptococcus. This organism, as its name indicates, is a little spherical body usually found growing in chains like a string of beads. It causes a great variety of diseases, the most common being the ordinary sore throat. It may, however, attack any part of the body and may cause both chronic and acute diseases. It affects the heart valves, and plays an important, if not the only, part in Rheumatism. It is found in diseases of the lungs and is common in Mastoid disease, from which, and in other ways, it often reaches the brain.

A VERY DANGEROUS GERM

The Streptococcus is also the cause of most cases of Puerperal Fever following child-birth. It is in this connection that the new antiseptic mentioned above is being tested. The Streptococcus is a germ which may be " carried " by almost anyone. That is to say, the germ may be present in or on the body without causing disease because of an existing immunity, but may pass to another person and produce the disease in all its manifestations.

This is quite a common occurrence in Diphtheria. Children who have had the disease often harbour the bacillus, especially in the nose, for a long time.

The Schick test shows that they are immune, but the germ is still virulent if passed on to a susceptible person. A " carrier," as such a person is called, may pass the disease to many.

MANY TYPES OF CARRIER

The " carrier " state may exist with quite a variety of germs. The typhoid bacillus, which usually disappears from the body when a patient recovers, occasionally finds its way into the gall-bladder and continues to exist there for years. Small numbers pass out of the body in the motion and may reach other potential victims.

As we shall see in a later chapter, diseases are carried by animals and insects, but in a civilized community the human germ-carrier presents a serious problem.

BLOOD-POISONING

The Streptococcus is also the commonest cause of " blood-poisoning," or Septicæmia. This is one of the most devastating forms of bacterial disease, for it is so often rapidly fatal and so often arises from a comparatively trivial cause. It is a danger to which doctors are particularly liable, and it is not uncommon for a surgeon at an operation or a pathologist at a post-mortem examination to give himself a very small needle-prick from which blood-poisoning develops.

In such a case the needle has carried into the skin a few virulent Streptococci which rapidly spread throughout the body. They multiply in the bloodstream, and they may settle in other and vital organs. It is to prevent such catastrophes that a new and potent antiseptic is being sought.

ANTISEPTICS AND MODERN SURGERY

It must not be imagined that we are completely powerless against the Streptococci. These germs, and others, were at one time the cause of death in a very large percentage of those who underwent an operation. Before it was recognized that bacteria could infect open wounds, deaths occurred after any and every type of operation that was attempted. The great work of Lister showed that these bacteria could be destroyed, and surgery began to achieve undreamt-of triumphs.

The methods of Lister, which aimed at destroying germs in the air, on the patient's skin, and the surgeon's hands, have been replaced by newer methods in which everything that is utilized at an operation is first sterilized—that is to say, all germs in or on dressings, ligatures, instruments, and so on are killed before these things are used. As a result sepsis after an operation is now a comparatively rare thing, and the surgeon can carry out operations on every part of the body without the fear that even if he does his part correctly infection and possible death will follow.

What this has meant in the fight against death it is almost impossible to estimate. Not only have pain and suffering been relieved in millions upon millions of cases, but every day—indeed every hour of the day—people are snatched from the grave by surgical skill. Such operations as removal of the appendix, the gall-bladder, the womb, and so on, are commonplace, and surgeons are to be found in nearly every hospital who can open the skull and remove tumours pressing on the brain.

We have no space, and it is not within the purpose of this book, to tell of the wonders of anæsthesia, which makes these operations possible without pain. Prevention and relief of pain is a very important part of the struggle against disease, for it is less easy for the patient who is suffering pain to withstand the attack of disease. Many and varied are the drugs used for this purpose, and few are the cases in which pain cannot be controlled.

A GERM IN THE WRONG PLACE

While the Streptococcus can be as dangerous as we have just mentioned, it is interesting to note that this ability to attack the human body is possessed only by certain Streptococci. It is not quite clear what the difference between the dangerous and the non-virulent is, but Streptococci can always be found in the mouth and throat without causing any apparent damage.

There are many other germs always present in or on the human body, especially in the alimentary tract. The number of germs present in the intestines is uncountable, and the waste matter which constitutes the daily motion is to a considerable extent composed of bacteria. These play a certain part in the process of digestion, and by far the most common germ is the Bacillus Coli. This causes no ill-health so long as it is confined to the intestines. It may, however, get into other organs, and we then find that this germ, which is a normal inhabitant of the human body, becomes a producer of disease. The most common trouble which it causes is Cystitis or inflammation of the urinary bladder.

This disease presents an interesting problem in treatment, for it is obvious that the best way to reach the invading germ is through the kidneys. Various drugs are used for this purpose, and the manufacturing chemist has sought for a substance which will pass through the kidneys without damaging them and still be capable of destroying the Bacillus Coli living in the bladder. Various substances have this property; but the difficulty is to get them sufficiently concentrated in the urine to kill all the germs. Mandelic

Acid, the latest urinary antiseptic, appears to do this in a very large number of cases.

GERMS WILL YET BE CONQUERED

We have given only a few illustrations of how germs cause disease, and have been able only to indicate what science does to combat them. There is no longer any need to speculate as to why germs should enter the human body and cause these diseases, for the matter has been proven over and over again by all the tests that modern science can devise. We know also many ways, such as those we have indicated above, of destroying these germs and preventing them having their full lethal effect on the human body. The subject is in some respects still in its infancy, but it can be claimed that we now know enough to feel sure that the science of the future will reveal ways in which all these germs can be conquered.

CHAPTER III

PARASITES

IN the last chapter we have made no attempt to discuss the obviously interesting and very difficult questions of why bacteria should exist, or of how they evolved. It has indeed been suggested that it was in some such lowly forms that life first began. How this took place is described by Zinsser in his book *Rats, Lice, and History* as the " great incomprehensible mystery." " Between the chemically definable protein molecule," he says, " and the living bacterial cell there is a gap of understanding far greater than that between the first living cell and man." Whatever the stimulus was that provoked this form of life, it presents us with other problems of which we can only suggest a solution. The chief of these is the question of why bacteria should attack a human body in the way they do.

GERMS LIVE AT BLOOD-HEAT

It has been found over a long period of years and during many thousands of experiments that the greatest number of bacteria grow best and develop in the most rapid fashion when kept at a temperature which is exactly that of the human body. There are a few which exist at lower temperatures, and there are some, for example, found living in such places as the hot springs of volcanic regions, which have become able to exist at a higher temperature. On the whole, however, germs of all types prefer the temperature of the human body. This may, of course, be an adaptation; but on the other hand it is probable that it is at about this temperature that those chemical changes which we call life go on most briskly. If this is so, then it is not surprising that bacteria, and, as we shall see, other parasites, find in the warm human body an excellent place to live.

It is not only microbes of the sizes and types briefly mentioned in the previous chapter that have found the warmth of the human body advantageous, but a number of higher forms also live parasitically in the human tissues. Certain bacteria, as we have mentioned, can enter the human body only when they find an abrasion or scratch in the skin which lets them through. Others, and particularly those which we shall discuss in the next chapter, appear to get into the body very easily through the nose, windpipe, and lungs. Others again enter, especially in foodstuffs, through the stomach and alimentary tract.

PARASITIC WORMS

This portal of entry has proved very useful to certain animals in the form of worms which inhabit the human intestines and spend the greater part of their existence there. They feed upon the human body and grow to full sexual maturity, and their ova or eggs pass from the body in large numbers and infect other animals or other men. The best known of these are the tapeworms, which are found in the domestic animals associated with man and also in certain fish. The tapeworm ova may pass from the animal direct to man, as in the case of those infecting the dog, or may be present in meat taken as food, such as pork. A slightly more elaborate cycle is necessary in the case of those that reach man in fish. It will be observed that at certain stages these parasites infect the muscles of the host, and one type may reach almost every part of the body and cause large cysts.

A STRANGE LIFE-CYCLE

There are a few forms of worm-like parasites which present the most amazing example of adaptation to a parasitic form of existence. The liver-fluke, for example, which is very common in sheep, passes through certain stages of its existence inside the body of the sheep. The greater part of its life is spent within

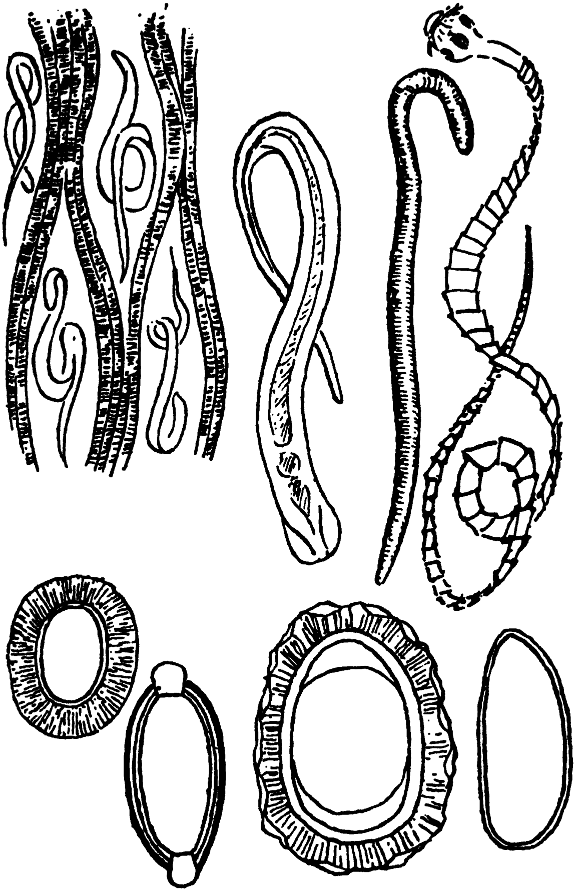

FIG. 3.—PARASITIC WORMS AND EGGS, TO SHOW THE DIFFERENT TYPES. (Not to scale.)

the sheep; but the eggs pass out, and if they fall on damp ground hatch into an entirely different form which infects not other sheep, but a small water-snail. They continue their existence in the body of the snail, but after a period of growth leave it and make their way to grass plants, where they again change, taking the form of small cysts attached to the grass. When these are eaten by a sheep, the cysts dissolve in the stomach and the young flukes begin their life inside the unfortunate animal.

Those who have studied any of the biological sciences have been amazed at the adaptations that have taken place in different species. There are, for example, those cases of plants which can be fertilized only by a particular type of moth at a particular time of the year, and cases of plants and animals which exist under conditions in which life would seem impossible. Nothing, however, is so amazing as the way in which parasites continue an existence which depends, like that of the liver-fluke, on finding two or even more hosts for different parts of the parasitic existence.

INSECTS AS CARRIERS OF DISEASE

So far as diseases in the human body are concerned, these adaptations depend to a large extent on insects which feed upon man and especially on blood. The most quoted example of this, and one of the first

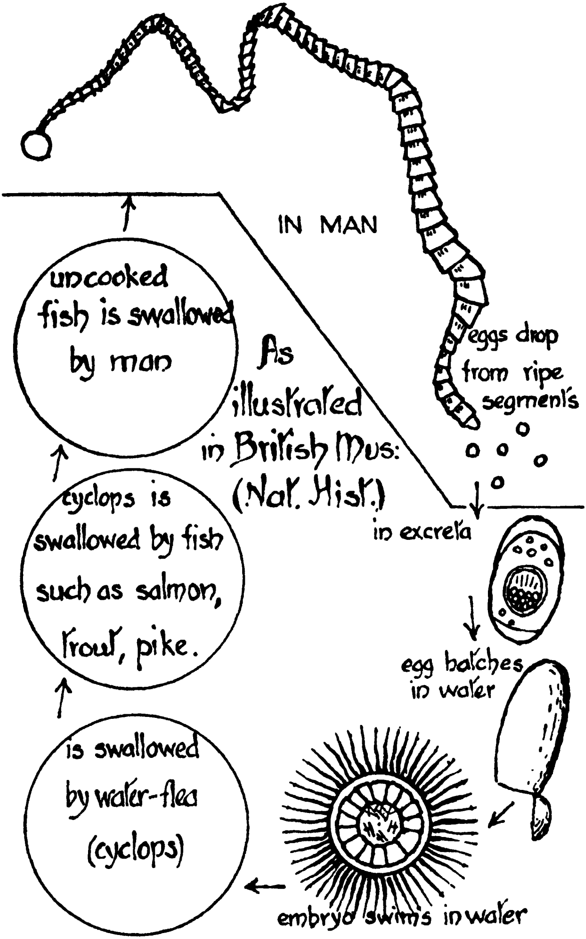
IN MAN
eggs drop from ripe segments
in excreta
egg batches in water
embryo swims in water
is swallowed by water-flea (cyclops)
cyclops is swallowed by fish such as salmon, trout, pike.
uncooked fish is swallowed by man
As illustrated in British Mus: (Nat. Hist.)

FIG. 4.—THE LIFE-CYCLE OF AN INTESTINAL PARASITE.

to be discovered, is that of the malarial parasite, which goes through one of the most elaborate of all life-cycles, for the completion of which it must pass from the body of man to that of a mosquito. All mosquitoes do not carry the parasite, although there is more than one type which may do so. The life-cycle is not a simple, straightforward development, for, in addition to passing from the human being to the mosquito and back again, the malaria parasite can exist in one of its forms and go through an asexual form of development and multiplication inside the human body. This asexual cycle goes on over and over again in the blood with a certain very definite periodicity which gives rise to the well-known periodicity of the malarial attacks. The parasite lives inside the red blood-cells, growing and dividing up into a large number of smaller forms which are liberated into the blood-stream and take up their abode in other red cells. At one stage, however, these may pass to a mosquito which has bitten the human being, and in the mosquito the form of multiplication is sexual.

EPIDEMICS STILL DANGEROUS

Malaria is, of course, a very serious disease, and it has been suggested that some of the great catastrophes that have overtaken civilizations of the past

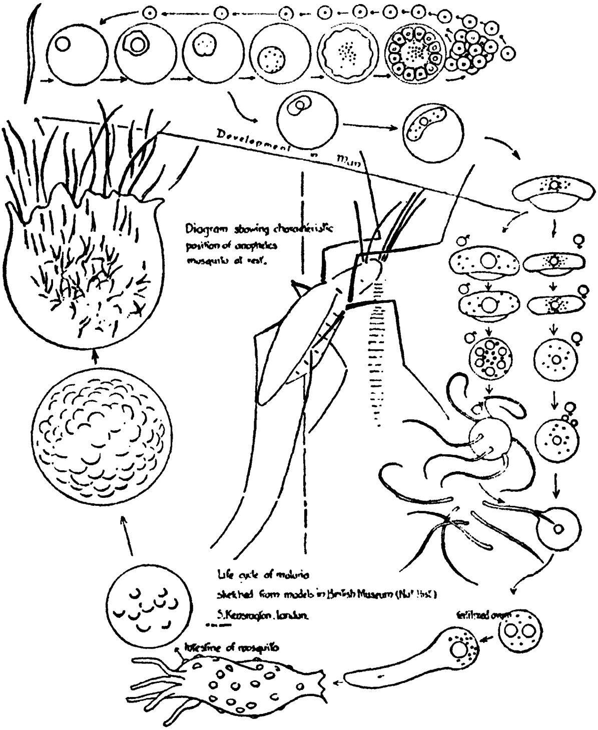
Development in Man
Diagram showing characteristic position of anopheles musquito at rest.
♂
♀
Life cycle of malaria
sketched from models in British Museum (Nat Hist)
S. Kensington, London.
fertilized ovum
Intestine of mosquito

FIG. 5.—THE LIFE-CYCLE, BOTH SEXUAL AND ASEXUAL, OF THE MALARIA PARASITE.

have been due to attacks of some such disease wiping out the population. That this is not an exaggeration was shown by the epidemic which occurred in Ceylon as recently as 1934. That epidemic spread with amazing speed, and it is believed that over one hundred thousand deaths occurred. It must be remembered that, since we know the life-cycle of the malaria parasite, it would appear possible to interfere with it effectively. For centuries it has been known that the drug quinine has a markedly curative effect once the disease has been established, and is also very effective in prevention. Since the part played by the mosquito was recognized it has been obvious that, if the mosquito could be destroyed in sufficiently large numbers in any particular area, the case rate of malaria could be reduced.

The methods needed for this have been described over and over again, and consist of destroying by drainage and other means the stagnant pools which form the breeding-places of the mosquitoes, or of rendering them unsuitable by spraying them with oil. In a discussion at the Royal Society of Tropical Medicine and Hygiene in reference to this, one speaker drew attention to " our powerlessness with our present knowledge, despite its great advance during the last fifty years, to prevent malaria epidemics or to control them when they have begun." Other speakers at this discussion took a less pessimistic view, while

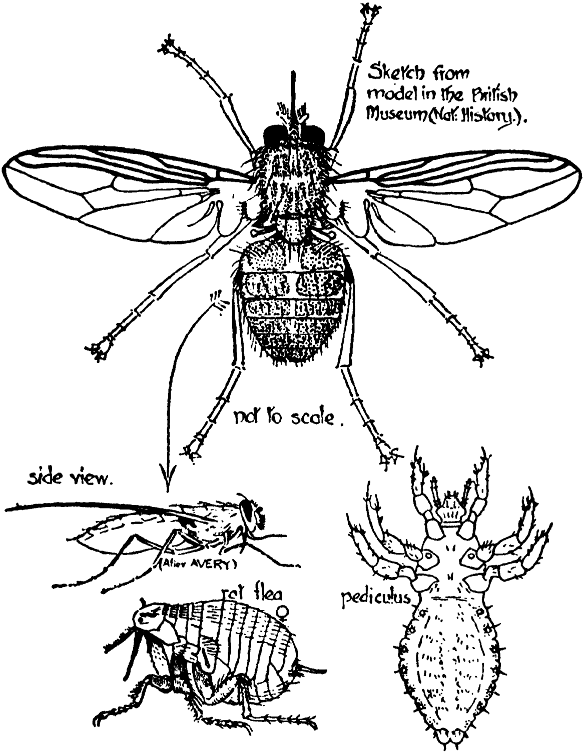

FIG. 6.—INSECTS THAT CARRY DISEASE.

emphasizing that the steps that would require to be taken were of very large dimensions and involved the spending of a considerable sum of money on a long-term programme, not only to discourage the malaria-carrying mosquitoes, but also to improve the general health and sanitary conditions of the inhabitants of such places as Ceylon, where these epidemics still occur.

INSECT-BORNE DISEASES

A very large number of diseases of this type are to be found in tropical and sub-tropical countries. The mosquitoes play an important part in conveying these diseases, and we shall discuss another of them in the next chapter when we describe the condition known as Yellow Fever. Other insects play their part, and scientists have found it a difficult problem to sort out the life-stories of all parasites of this type. We should have said that these parasites are very different from the bacteria which we described in the last chapter. They are also unicellular organisms, but belong to the class of protozoa, and not only do they have an elaborate life-cycle, but reproduction is to a considerable extent a specialized process.

One of the most important of these protozoa is that which causes sleeping sickness, which is still very prevalent in tropical countries. The chief form of the disease occurs in Africa, and infects both man and animals. The parasite, which is called the Trypanosome, is carried from man to the animals and back again by the biting insect known as the tsetse fly.

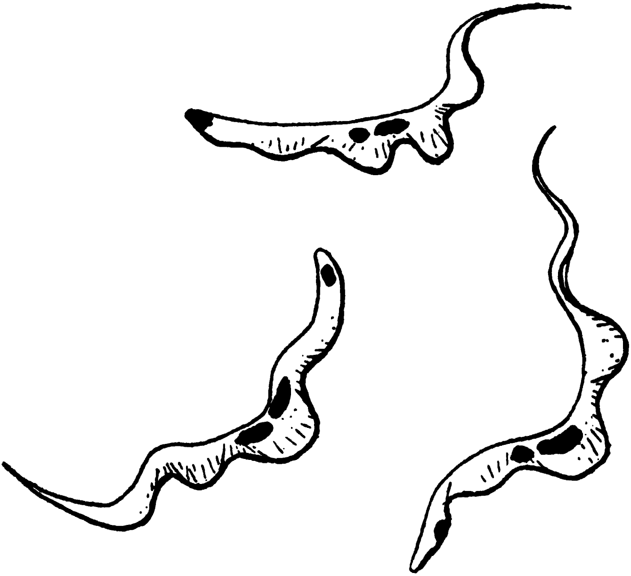

FIG. 7.—TRYPANOSOMES, THE CAUSE OF SLEEPING SICKNESS.

Great advances have been made in ridding large areas of this disease by removing the type of jungle country which favours the breeding of the tsetse fly, and this is particularly important, as treatment remains difficult despite the advance made by the preparation of chemicals which can be administered to human beings and are definitely destructive to the parasite.

We must briefly mention another class of parasites, the Filariæ, conveyed to human beings by biting insects. These also occur mainly in tropical countries, and produce a very peculiar condition known as Elephantiasis. This name is given to the disease because the parasitic worms tend to block the lymph channels through which the tissue fluid is carried back to the blood-stream, with the result that the affected part, usually the leg, becomes enormously swollen and has the shape and appearance of the leg of an elephant.

INSECTS ALSO SPREAD TYPHUS FEVER

The mosquitoes and insects of that type are not the only ones concerned in carrying disease. One of the most important and deadly of all diseases, Typhus Fever, is carried by lice, and in some cases by other insects feeding upon man. Typhus Fever infects not only man, but also the rat, and it is in the rat that the disease continues to exist. It is as deadly to the rat as it is to man, and on the death of the rat the lice look for a new host, and may find it in man. It is therefore a disease associated with bad sanitation and overcrowding, and it has always been very common during war-time. It has been known for over eight hundred years, and Zinsser, in the book which we have already quoted, makes a claim that this disease has had more effect on history than the intentional actions of mankind. Even in the Great War Typhus Fever became epidemic in Serbia, and this is said to have had a considerable effect on the course of the War.

We must also mention at this point another disease infecting rats and spreading from them through the flea to man. This is Plague, caused by the Bacillus Pestis, and, as everyone knows, this has from time to time caused disasters in which many thousands of people have been killed. This disease has been known for many hundreds of years, and in the thirteenth and fourteenth centuries caused epidemic after epidemic in all parts of Europe. It has been calculated that at least twenty-five million people died from this disease at that time. The last great epidemic in this country was the Great Plague of London in 1665, when over thirty thousand people perished. For some reason which has never been quite clear that was the last real epidemic in this country, although it still persists in other parts of the world, where overcrowding and bad sanitation give the rat a chance to breed and to act as a reservoir for the disease from which human beings can be infected. Even in those areas science has been able to help, for by means of a vaccine those coming into contact with the disease can be rendered immune.

ANIMALS ALSO CARRY DISEASE

Before concluding this chapter we must again emphasize that man is constantly in danger from parasites and bacteria infecting other animals and capable of causing disease in the human body. Some of these diseases are of comparatively low virulence in communities which have become familiar with them. Thus we have the condition known as Malta Fever, which infects the goats of that island and passes from them to human beings in the milk. When the cause of this disease became recognized the solution was obvious, and by getting rid of the infected animals the disease was almost entirely banished from the island of Malta. We have in this country a closely-related germ, Brucella Abortus, which infects cows, and may also pass from them in the milk to human beings. Fortunately this disease, while it causes serious illness, is seldom fatal.

DANCERS IN FOOD

There is also a danger to man in some of his foodstuffs, for he may eat the flesh of animals already infected by a parasite. If it happens to be a parasite such as the Trichina Spiralis, which can exist in an encysted form in the muscle of such an animal as the pig, it can pass through the stomach wall of anyone who eats pork which has not been sufficiently cooked to destroy the cysts. It often makes its way through the body of the host and settles down in the muscles in the encysted form. If these are present in large numbers or at important places they may cause serious and sometimes fatal disease.

The bacteria may pass to man also by means of food, and there is a long list of germs which form what are known as the food-poisoning bacilli. These can be very dangerous to mankind; but they are, of course, conveyed only in food which has been contaminated either during or after the process of preparation. There is one germ—the Bacillus Botulinus—which produces poison so potent that its presence in foodstuffs may cause disease and death. There have been comparatively few outbreaks of this, and modern methods of preparing the type of food in which it might exist are usually quite capable of preventing the development of this germ.

THE SKIN ATTACKED BY PARASITES

The skin is quite naturally in constant danger from the attacks of parasites and bacteria. Some of those that invade the skin are fungoid in nature, Ringworm being a common example. Other forms attack the nails and prove very difficult to destroy. The infecting agent in these cases lies somewhere between the larger bacteria and the lower forms of plant.

There is also the condition of the skin spoken of as "itch" in which a small animal parasite burrows into the skin. In the tropics there are other parasites which burrow into the skin.

In these and many other ways protozoal parasites and bacteria gain entrance to the human body. All of them, as we have mentioned, are associated with such conditions as uncleanliness, bad sanitation, overcrowding, and lack of attention to the safeguards which are now universally regarded as necessary. Most of these diseases are deadly to the individual, and some of them are of very serious importance to the community as a whole. For all of them there is the one solution: the acceptance of what science has found out about their method of passing from an animal or other source to the human body and the taking of steps to prevent that passage. For most of them the methods are already known, and all that is necessary is a combined and vigorous effort, unhampered by lack of finance, on the part of the affected communities.

CHAPTER IV

INVISIBLE FOES

It will be obvious from what we have already said about the class of disease that is due to living agents that one of the first steps science must make if it is to have any chance of being successful is to identify and discover ways in which it can readily recognize the disease-producer. Before the discoveries of Pasteur medicine was groping all the time in the dark, trying to cure and prevent disease of the cause of which it had no true conception. With the discovery of bacteria medicine acquired new strength, for, while these enemies of mankind remained invisible to the eye, methods were developed by which their presence could always be discovered. As soon as one bacterial disease had been recognized it was clear that most of the febrile and contagious illnesses must be bacterial in nature, and starting from this point germ after germ was rapidly identified.

GERMS MAY BE SECONDARY TO OTHER CAUSES

On the other hand, it was not long before it had been clearly shown that there were certain feverish conditions which had the general characters of bacterial disease, but in which no germ of any kind could be found. In some cases germs were present and for a time were thought to be the true cause of the disease. An example of this is Influenza, in which a small bacillus with well-recognized characteristics is very often found in the nose and throat of sufferers. This germ was indeed called the Bacillus Influenzæ, and it was only the failure to reproduce the disease by means of these germs that raised any doubt as to its causative nature. It is only in the last year or two that it has been clearly shown, in the first instance by research workers at the National Institute for Medical Research in Hampstead, that the true cause of Influenza is an agent of another type. The real position now appears to be that this agent, which we shall describe in a moment, begins the disease, and that the Bacillus Influenzæ and other germs take advantage of the diseased condition of the body to flourish and to attack the tissues secondarily.

The real agent belongs to an entirely different class, as we have already said, and is known as a virus. For the moment science is up against a very great difficulty in this connection, for the viruses are so small that our usual methods of examination and magnification are valueless. Before the image of any object can be magnified it must be of such a size that it interferes with light waves, which we know are of definite length. An agent which is less than the smallest size that can interfere with light waves cannot be seen by the microscope, and is therefore spoken of as ultra-microscopic. It follows that some of these viruses must be for ever outside ordinary human vision; but science is seldom defeated by a problem so clearly defined, and special methods have been sought for obtaining some kind of view of these minute organisms. There are a few on the edge of visibility, and apparatus has been devised by means of which some of these can be made to give an image visible to the eye or to a photographic plate. The viruses seen by these methods cannot be said to be identified as are the larger bacteria, which can be stained and clearly seen under the microscope, but at least they are shown actually to exist.

PROOF THAT VIRUSES REALLY EXIST

Since they cannot be seen by ordinary methods the presence of viruses requires to be shown by other means. One means, and one which definitely proves their connection with disease, is to pass them to other animals. There are quite a number of virus diseases which produce very definite and easily recognized effects in the usual experimental animals. If material from a human case of a disease thought to be virus in origin is conveyed to such an animal the effects can be recognized although the infecting agent cannot be seen.

Such material can be taken directly from a case of the disease; but it may then be objected that other agents, either bacterial or chemical, may be causing the effects seen in the animal. It has been found that, on account of their exceedingly small size, viruses can be separated from larger objects by filtration through some material of a porous nature. Filters of different types have now been prepared of such materials that the size of a particle which will pass through is fairly accurately known. That is to say, all particles above a certain size will be retained by the filter, while all those below a certain size will pass through it. If material containing a virus is passed through such a filter the virus can be separated from other elements, and is therefore described as a filterable virus, since it passes through the pores.

VIRUS AND BACTERIAL SIZES OVERLAP

Viruses and bacteria possess many different characteristics, but there is no hard-and-fast line between them. Just as bacteria vary in size so do viruses, and when they are arranged in order of size as in Fig. 8 it is seen that the smallest recognizable bacteria

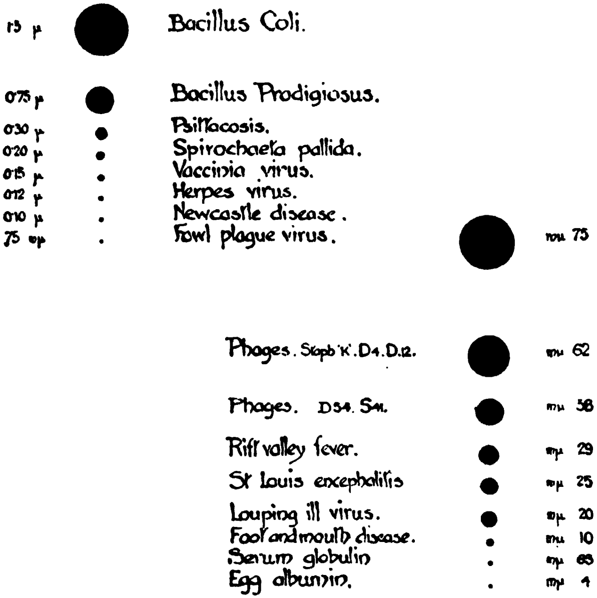

FIG. 8.—SIZE RELATION OF BACTERIA AND VIRUSES.

Commencing at the bottom of the right-hand column with a molecule of albumin, the size increases through the viruses and bacteriophages until bacteria are reached.

are of a size similar to that of certain large viruses. The smaller viruses, however, are of a size which is little if any larger than single molecules of certain organic chemical substances.

In speaking of the bacteria we said that one part of the proof that they cause disease was obtained by growing them outside the body and then reproducing the disease from these isolated cultures. It has been regarded as essential in the case of the bacterial diseases that the organism must be grown artificially before it can be definitely labelled as a disease-producing germ. Most of the germs have their own way of growing and produce very definite appearances in artificial culture media, but in the case of the viruses this step in the proof that they cause disease is so far lacking. A large germ such as a common coccus or bacillus produces a growth on the surface of a culture medium which can be seen by the naked eye. So far no virus has been found of which the same can be said. Some evidence has been collected that viruses do multiply under artificial conditions, but the evidence is of a highly technical kind and does not permit of the simple demonstration that is possible in the case of the larger bacteria.

Another difficulty is that the viruses do not appear to utilize the same type of foodstuffs as are used by larger micro-organisms, and there are therefore some people who are disposed to doubt that they are really living. However, certain definite changes can be shown in artificial media in which viruses have been placed, and these changes point to active growth and to utilization of chemical substances for food. At any rate, the diseases with which a conception of a virus is associated are all of a type in which one would expect to find some living agent, and all the tissues of cases of these diseases show changes which are very characteristic.

SOME VIRUS DISEASES

One of the first of the diseases of this type which was investigated was Rabies, at one time common among dogs all over the world and frequently infecting human beings from the bite of animals suffering from the infection. That the disease is infective cannot be doubted, for the bite of an animal at a particular stage invariably leads to the development of symptoms in the bitten person. Although no causative agent could be found for this disease, Pasteur was able to elaborate a method of treatment which is still carried out, and which corresponds very closely to methods used in other conditions which we know are bacterial in origin.

Dogs are also subject to another disease which in recent years has been shown to be due to a virus.

This is Distemper, which everyone knows is very common among dogs, and which is highly infectious when they are herded together. The search for the virus of Distemper revealed all the usual difficulties associated with a virus disease. The agent could not be grown visibly and could not be seen under the microscope, and for a long time it could not be passed on to any other animal. This is always a great difficulty in the investigation of a bacterial disease. If the ailment is one which is dangerous to one of the animals usually used for laboratory experiments, the investigator has at least a chance of solving the problem. Some diseases, however, do not affect the ordinary small animals, or cause a condition which does not resemble that in the human being. In the case of Distemper in dogs progress was slow until it was discovered that the ferret was highly susceptible to the disease, and by well-controlled experiments on these animals it has been clearly shown that the cause of Distemper is a filterable virus, and furthermore that by the use of certain products obtained from the infected ferret a considerable degree of immunity can be conferred on dogs.

There are a large number of virus diseases which cause trouble in the animal kingdom, and another very interesting one is found in sheep. This virus produces a disease of the nervous system with such characteristic symptoms that the disease is known as Louping-ill. It is almost entirely restricted to certain areas, and for a long time was thought to be without any danger to man. Quite a number of laboratories took up the study of this disease, and many laboratory workers came into close contact with the virus. Under these conditions it was found that this virus can infect man, and a number of cases of the disease in laboratory workers have occurred. This virus cannot be seen any better than others of its class, but another stage in the proof of its living nature and its relation to bacteria has been found in the fact that the blood of those humans who have had the disease contains antibodies which are capable of neutralizing the virus.

HOW VIRUSES ARE CARRIED

Most of the viruses appear to be conveyed directly from one victim to the other ; but, as with all diseases due to living agents, there are some which reach the human host through the medium of an animal or insect. Rabies, which we have just mentioned, is of course usually conveyed by the dog. A year or two ago, however, it was discovered that on the island of Trinidad certain cases of an unusual nervous disease which had occurred were really due to this virus, and after an elaborate investigation it was found that the disease also occurred in some cattle on the island, and that the host conveying the virus from the animals to man was a type of vampire bat.

Insects also convey viruses, and two diseases are of particular interest in this connection. The agent causing Typhus Fever has not yet been identified, although certain microscopic objects occurring in animals and insects infected with the disease are thought to be the virus. This disease, as we have already mentioned, has been of immense importance in historical times ; it has been the cause of an enormous number of deaths, and is conveyed to man by lice and fleas.

MOSQUITO ALSO A VIRUS-CARRIER

The mosquito, in one of its forms, conveys another virus disease which has for centuries taken toll of human life. Yellow Fever occurs in certain tropical countries, and was perhaps the chief cause of death among those who first tried to build the Panama Canal. In those areas where it occurs it spreads with great rapidity among the susceptible members of the community, and the death-rate from it is very high. It is now known to be caused by a filterable virus, but the part played by the mosquito had been recognized for a long time. The story of the American investigators who proved this point makes fascinating reading.

The experiment had to be made with human beings, since no animal is known in which the disease can be reproduced. They also had to rule out suggestions that contact with sick people or with clothes which they had worn was necessary, and to do so they shut themselves up in a hut with all the supposed infectious agents, but from which mosquitoes had been excluded. None of them took the disease, but they did not consider that that was sufficient proof, for there was just a chance that they might have been naturally immune to it. To make the proof absolutely certain, it was therefore necessary to expose themselves to the bites of mosquitoes which had come from those already ill with Yellow Fever, and when they did this they became infected with the disease. Considering the risk that they were running, this probably ranks as one of the most heroic deeds ever done by man; but it has given mankind as a whole a definite proof that Yellow Fever can be prevented if the disease-carrying mosquitoes are destroyed.

SOME COMMON VIRUS INFECTIONS

Before leaving this subject we must again discuss another virus disease of great importance to humanity as a whole. Influenza, particularly on those occasions when it strikes the whole world with epidemic force, is a disease to which everyone is susceptible and to which a large number of people succumb. As we have already mentioned, a small but quite easily recognizable germ is usually present in the nose and mouth of those suffering from the disease, and was thought to be the actual cause of the disease. It was recognized, however, when Distemper of dogs was shown to be due to a virus, that Influenza and Distemper had certain resemblances. This clue was followed up, making use of the ferret, which, as already mentioned, is susceptible to Distemper ; and British research workers were able to show that a disease resembling the influenza of human beings and constant in the symptoms which it produced could be transmitted from human beings to ferrets and from one experimental animal to another. It was shown that this could be no recognizable germ, but belonged to the class of ultra-microscopic viruses.

It is strange that many viruses have a preference for the brain and nerve-tissues as the centre in which to grow. Another virus disease, Encephalitis Lethargica, or sleepy sickness, is of this type, and caused much anxiety some years ago. It spread over the whole world, and cases were numerous ; but for some reason it once more lost its virulence, and very few cases have occurred in recent years.

This disease causes very definite damage to the nerve cells, and long after the acute disease has been apparently cured the patient may develop other symptoms from the number of nerve-cells that were destroyed in the acute stage. This destruction of nerve-cells is also a familiar happening in other diseases, for Infantile Paralysis is due to this, and is also the result of a virus infection.

This branch of medical bacteriology is still at the stage of accumulating facts, and we are not yet in a position to define with any clarity the actual nature of the viruses. Their importance, however, is tremendous, for we must add to those diseases which we have already discussed such widespread infections as Measles, Chicken Pox, and Small Pox, among those caused by the viruses, and in this field science can only be said to be collecting weapons with which we can safely hope it will one day conquer these death-causing agents.

CHAPTER V

STRUCTURE AND HEALTH

IN the preceding chapters we have been concerned with enemies that attack the human body from the outside. We have also been able to suggest that, both by its own mechanism and by the assistance that science can give it, the human body has many ways of overcoming the diseases that are due to infective agents and parasites. There are, however, a large number of diseases and defects that may occur in the human body without, so far as we are aware, any action on the part of outside agents. This is not altogether surprising if we consider for a moment how the human body develops.

Every human body begins as a single cell, from which, by a process of repeated and rapid division, the uncountable cells that make up a human body are provided. To begin with, the cells that divide off in this way are undifferentiated, and as the process of development goes on groups of cells are set apart to develop in a variety of ways into the separate organs and tissues of the body. That development is not a straightforward process, for in the course of it the developing fœtus retraces to a considerable extent the evolutionary development through which the human race has reached its present stage. There are therefore many possibilities for developmental defects.

In the first place, some of the cells may retain their primitive form and fail to fit into their proper position. When that happens we may have produced a particular type of tumour growth which will show itself, according to its nature, at various times in life, often with fatal results. A further abnormality that may arise is that, although the cells have become correctly differentiated, the organ which they are to form may be misplaced or incomplete. Occasionally an apparently normal human being may develop in whom one organ is entirely missing, or present only in rudimentary form, and examples have been found which cover almost every organ of the body. Thus it is no uncommon thing for a child to be born with one or other of the many bones in the body absent or represented by only a very small and rudimentary bone.

SURGERY CAN REPAIR CONGENITAL DEFECTS

In these cases it is worth while noting that modern surgery has been able to produce some of its greatest miracles; for a piece of bone may be taken from one part of a body and grafted on to another where it will grow, not into the bone which was removed, but in the shape of the bone which it replaces. Grafting one living thing upon another has long been a recognized process, especially in the case of trees and plants. It is now possible to take healthy living tissue from one person and transplant it to another. This is a comparatively common procedure in cases where the skin has been destroyed, as in exterior burns. Sometimes it is possible to take small areas of skin from a healthy part of the patient's own skin and graft them on to the burned area, but occasionally it is necessary to take it from another person.

MAKING NEW FACES

The skin is a comparatively plastic tissue, and the skilful surgeon can do a great deal with it in repairing damage to such parts of the body as the face. Special kinds of graft are necessary, but once they have been made successfully new ears, new noses, and even new lips, can be formed. This form of surgery came into prominence during and after the Great War, when many soldiers had terrible facial injuries restored to something approaching normal. Although some opportunities for such surgery do occur in peace time, there are very few surgeons who have special skill in it, and it has been suggested sardonically that we are not training our surgeons correctly for the next war.

Deformities and congenital absence of bones may, as we have suggested, be relieved by grafting. Thus a rib has been used to reproduce a jaw-bone missing from birth. There is nothing more marvellous than the way in which the body-cells replace bone that has been removed or set about repairing a broken bone.

From time to time our daily newspapers publish stories of girls who have, by a surgical operation, been converted into men. These are usually cases of congenital defects, due to the complicated way in which the sex organs develop, and the surgeon does what he can to shape the tissues more definitely into one of the sexes.

ANOTHER TRIUMPH

A recent grafting triumph has been in the case of the eye, a most delicate organ and one in which repair of injury is always difficult. When the clear part of the eye, the cornea, has been damaged by disease or injury, it may become so opaque that light cannot pass through it and sight is impossible. If the opaque matter could be removed and a clear cornea restored vision would again be possible. The operation is one of great difficulty, requiring the utmost care. It can be attempted only when another eye is available—one from a patient whose cornea is clear and undiseased, but who for other reasons can never see.

OTHER ABNORMALITIES

Certain organs may be entirely missing, and whether the body can survive depends on how essential to it is the function of the absent organ. It is not an uncommon thing to find that people go through life with only one kidney, and that this increases in size and will serve the body almost as efficiently as the usual two, unless it should be so unfortunate as to be stricken with one of the diseases which attack the body from outside.

A further abnormality of which there are many interesting examples is that, instead of passing through those stages of development which recall the evolution of man's ancestry, an organ may stop growing while in this evolutionary stage. If this happens to a vital organ like the heart it may leave a defect which is incompatible with life. If it happens, as is not uncommon, in those developmental structures which represent the gills of the fish it may produce minor defects such as small cysts, which can be dealt with by the surgeon. Some of the developmental errors that occur have very little or no effect on life, among these being the condition in which the organs of the body are all placed on the wrong side. They are present, and they function quite well, but are placed in positions opposite to those which we recognize as usual.

STRUCTURAL DEFECTS DUE TO DISEASE

Mention of the heart reminds us that defects in this organ may produce severe and widespread change in the whole body. Everyone is familiar with the person who has heart disease and cannot live a normal energetic life. A defective circulation does not permit of normal function in any part of the anatomy.

Bacteria may attack the valves of the heart and leave so much damage that they cannot control the flow of the blood. Such disease is sometimes acute, but more usually chronic, and may produce secondary change in many organs. The small vessels feeding the heart itself, the coronary arteries, are also frequently the seat of disease which causes the walls of the blood-vessels to become hardened (and therefore less efficient) or even blocked.

The whole circulating system is often the seat of these thickening and narrowing processes, which lead to degenerative changes in the organs thus deprived of a full blood supply. This is the process associated with old age, and it leads gradually to a loss of function in the organs most affected. There is not space here, however, to discuss these forms of structural change.

Sometimes the process of development seems to go a stage further than is normal, and people are born with a few extra organs. The most common of these are extra fingers and toes, which may or may not be inconvenient. If they are, the surgeon is usually able to deal with them. It is of interest, however, that this appearance of supernumerary digits is hereditary, and may pass from one generation to another. The defects that may arise in one or other of these ways are too numerous to describe. Most of them are quite compatible with life if they are dealt with surgically, which usually involves surgical operations of the greatest delicacy.

THE ENDOCRINE GLANDS

Those who have read any book on how the human body as a whole functions will have learned that the perfect working of all the various organs is dependent on the presence within the body of certain small glands—the endocrine glands—which produce and pass into the blood-stream secretions that are vital to life. These internal secretions, as they are called, are in some ways the real controllers of the human

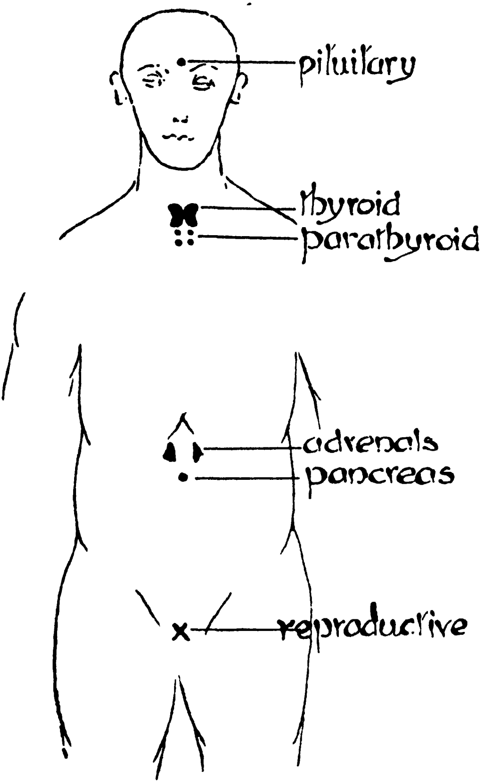

FIG. 9.—THE POSITIONS OF THE ENDOCRINE GLANDS.

race. They all interact together, and, although they are present in only very small quantities, nevertheless in a normal person the amount of each appears to be kept under very delicate control. It is by the internal secretions that such processes as those of growth, of sexual development, the size and shape of the adult body, the appearance of hair, and even the mental outlook and temperament, are decided.

It is rather difficult in a short space to give even a suggestion of how the different endocrine glands work, and, since we are concerned primarily with the defects that may arise in the human body, we will consider this subject only from that point of view. The endocrine glands are, of course, subject to the developmental errors which we have just been describing, so that even at a very early period of life abnormalities in this source may arise. One of the commonest of these is the presence of a tumour in the adrenal gland, which, by exciting the other endocrine glands, may cause a child to be precocious mentally and physically.

The endocrine glands are also subject to infectious diseases and other injuries which may destroy or interfere with their function. The adrenal gland just mentioned is occasionally the seat of an infection with the Tubercle Bacillus, which produces an easily recognized condition of ill-health and weakness. The adrenal gland is of particular interest to us, for it illustrates one of the advances that has been made by science in elucidating the work of the ductless glands. It is now known that the adrenals make a substance called Adrenalin, which passes into the blood, particularly at times of stress such as fear or anger. Adrenalin has now been isolated in a pure form, and can actually be manufactured artificially. Its most important effect is on the blood-vessels, and it is therefore much used by doctors in stopping bleeding.

A FAMILIAR GLAND

The gland most familiar to everyone is the thyroid, which lies in the neck in front and on either side of the windpipe. This gland is probably the chief controller of the bodily activities, and regulates the rate at which the body uses up its supply of foodstuffs. All of us must utilize a certain minimum amount of food, and this minimum is greater or less than the average, according to the way in which our thyroid gland acts. If the thyroid produces too much of its internal secretion, then all parts of the body work too fast and we have the person who is thin and energetic. If this goes on to excess we have a definite disease produced. In this the heart beats too quickly, the patient is in a very nervous state, and the eyes bulge in a way which gives the disease its name of Exophthalmic Goitre.

The thyroid gland may, however, produce too little of its secretion, and in this case we have the reverse effect. Everything in the body is slowed up, food is stored instead of being utilized, and there is a tendency for the heart and the brain to be slow. The exact effect produced will depend on the stage of bodily development reached before the thyroid gland ceases to function properly. If this occurs early in life the body and mind fail to develop, and the child will be a Cretin of small stature and very deficient mentality. If the disease occurs in adult life the mental processes are again slowed up, the skin becomes rough and coarse, and in general the bodily functions are slower.

THYROID DEFICIENCY CURABLE

Whatever the type of thyroid deficiency, we can safely claim that science has conquered it. The internal secretion of the thyroid has been isolated and its chemical formula is known. It can be manufactured and administered to those patients who are lacking in it, and in both the child and the adult it produces a remarkable return to normal. Where the thyroid is over-active the surgeon is able to remove a large part of the gland, so that the amount of secretion getting into the blood is reduced to something like the normal level. We should mention in passing that the thyroid gland utilizes a large amount of the iodine that enters the human body, and in some way its size is influenced by the presence of that element in our food in the small quantities in which it is usually found.

Space does not permit us to tell the fascinating story of how science has worked out the functions of these glands. Everyone knew, of course, that there were differences in human beings both as to physical and mental attributes, but it was not until the first of the glands of internal secretion was recognized that any idea existed as to why these differences in human beings should occur. Some of the glands are exceedingly small, and all of them produce their secretions in very small amount, so that medical science has had to devise all kinds of new methods of tracing the functions of the different secretions. The pancreas gland will serve as an example both of the difficulties and of the triumphs finally won by medical research.

THE PANCREAS AND DIABETES

The pancreas gland, or sweetbread, had long been known as the gland which pours through its duct into the stomach the juices that are necessary for digestion. It was also known that, while certain organs of the body could be removed without fatal result, the pancreas could not be removed from an animal without its dying. The death, however, was not like one due to the absence of the digestive juices, but of an entirely different kind, which corresponded closely to the disease known in human beings as Diabetes. In this, as everyone knows, the patient has an unusual thirst and desire for sugar, and the latter substance appears in the urine. It was these symptoms that developed in any animal from which the pancreas gland had been experimentally removed. This effect could not be due to the ordinary secretion of the pancreas, and it was traced to the presence, mixed up with all the cells of the pancreas gland, of another type of tissue which we now know is one of the endocrine glands. The cells of this gland occur in the pancreas in small groups, the Islets of Langerhans.

The great difficulty in proving this idea was that these islet cells could not be separated from the ordinary cells of the pancreas. The presence of the digestive juices in the pancreas prevented the isolation of the secretion of the endocrine portion of the gland, as this was destroyed by the other juices when the gland was removed from the body. It had been noticed, however, that in certain diseased conditions, when the

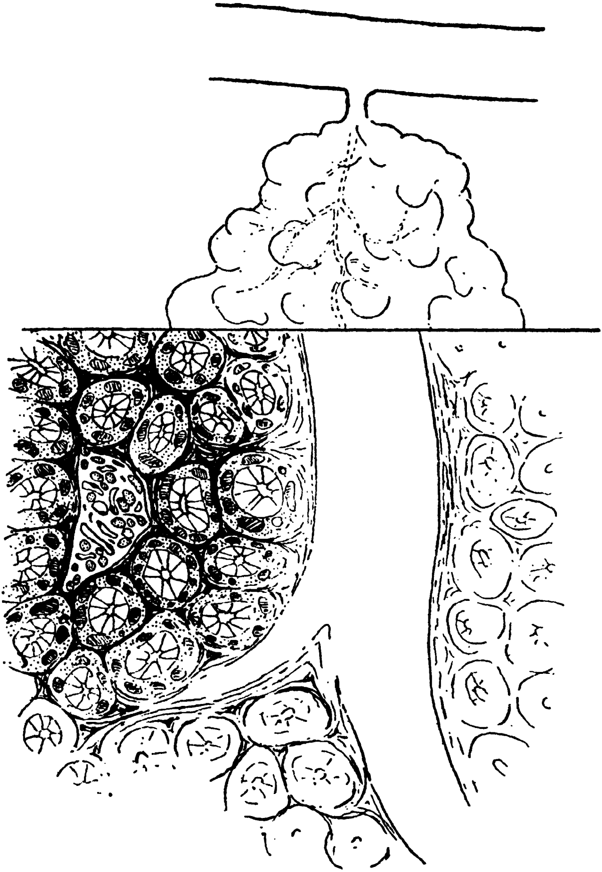

FIG. 10.—THE PANCREAS.

Above the line the naked-eye structure is outlined: below, greatly magnified, are the digestive-juice glands with an Islet of Langerhans among them.

pancreatic gland got blocked for a long enough time, the pancreatic tissue died, leaving the islet cells unharmed. This effect was produced experimentally in dogs, and, when the pancreas in which the digestive juices had thus been abolished was removed it was found possible to isolate the secretion of the islets, which was then given the name of Insulin. It was then obvious that it was the removal of this substance from an animal which produced the symptoms which had long been recognized as Diabetes. The triumph of science was complete when it was found that by the injection of the insulin these symptoms could be abolished.

INSULIN A WONDERFUL SUBSTANCE

Insulin is now available in a chemically pure form, and is in everyday use by diabetics all over the world. Its power to control the symptoms of Diabetes is universally recognized, but experience shows that it is not yet possible to reproduce precisely the delicate control which the normal islet cells have over the utilization of sugar within the body. Science has defeated death from lack of the natural insulin, but it has not yet found the correct method of replacing it in the body. The problem is to some extent a chemical one, and in the early months of 1936 an announcement was made that suggests the chemists are on the verge of discovering the necessary method.

It has been found that insulin can be combined with another chemical in such a way that when injected under the skin it is taken up by the blood very slowly and comes very near to reproducing the normal state of affairs.

Perhaps it should be explained that the normal state of affairs in this respect is that the amount of sugar present in the blood is kept at a very constant level. Any excess, from newly eaten food, is stored by the liver, and any deficiency, if the muscles are using up much sugar, is made up by sugar leaving the liver. This is all controlled by the amount of insulin present in the blood-stream, and it appears that this leaves the pancreas only in the amounts required.

CONTROLLING THE SKELETON

There are two other endocrine glands which are chiefly concerned with the human skeleton. The first of these, the pituitary gland, lies at the base of the brain inside the skull. It is a small gland about the size of a hazel nut, but it controls the extent to which the bones grow. Occasionally it over-acts and produces the disease called Acromegaly, in which the skull is very much thicker than usual, the jaw-bone increases in length, and the hands and feet become very large. If the pituitary over-acts in this way while the bones are actively growing during adolescence, there may be produced a person of a much more than average stature.

Bones can be formed only if the element calcium is present in sufficient quantity. Normally the amount of calcium in the blood remains very constant, and this, it has been found, is under the control of four glands little more than a pin's head in size, called the parathyroids. They take their name from the fact that they lie close to the thyroid gland in the neck. So long as they are present and producing the secretion in the right amount, bones are formed of normal hardness, because they contain the proper amount of calcium. Occasionally, however, the parathyroids produce too much secretion, as may happen if one of them grows into a small tumour, and the body is then unable to retain calcium in sufficient amount. Chemical analysis will show more than the normal amount of circulating calcium in the blood and more passing out of the body.

BONES EASILY BROKEN

As a result of this the calcium of the already formed bones begins to decrease, and the bones become more and more brittle and are liable to sudden and repeated fractures. In one famous case nearly every bone in the arms, legs, and chest had been broken before the true nature of the trouble was recognized.

A skilful surgeon removed a small tumour of one of the parathyroid glands, and at once the patient's body began to absorb and retain calcium. Bones became hard again and fractures joined up into good firm bone.

DOUBLE FUNCTION OF THE REPRODUCTIVE GLANDS

An exceedingly complicated part of the story of the endocrine glands concerns those connected with reproduction. Just as the insulin-producing gland has become mixed up in the pancreas, so the reproductive gland contains cells which produce an internal secretion. It is the activity of these cells which controls the normal development of puberty and causes the appearance of the secondary sexual characters. In the female the reproductive glands have a multiplicity of secretions which science is still struggling to separate. These secretions control the whole process of reproduction, and on their presence at the right time and in the right amount depend the occurrence of normal conception, development, birth, and feeding of a child. Sex abnormalities of varied degrees are particularly common, and there is every hope that when all the different internal secretions of the reproductive organs have been identified we shall have at our command weapons that will enable us to control the development to full maturity of both sexes.

It is quite impossible to give here any indication of the real complexity of this problem. The recognition of the part played by the internal secretion of the reproductive glands has provoked an enormous interest, not only in the medical profession, but also among the lay public. Since the ultimate control of growth depends on these secretions it is a fairly obvious idea that by their use the body might be kept young and active. From this there has grown up a considerable belief in the rejuvenating power of preparations made from sex-glands. It cannot be denied that these glands might have some such effect, but so far the claims made for various preparations have not been substantiated.

STRANGE CHEMICAL DISCOVERIES

On the other hand, the chemists who are concerned with these investigations have discovered certain potential dangers. Chemically it appears that one of the sex hormones is closely linked to substances derived from tar which are known to have the power of causing cancer in experimental animals. The particular hormone—œstrin—is one which is already fairly widely used, and, while at the moment it has not been shown that this substance has any effect on the production of cancer in human beings, its chemical relations cause it to be viewed with suspicion. There are still those who doubt the scientific basis of modern medicine; but the discovery of such facts as these, the working out of elaborate chemical compositions, and the testing out of the final products, give an indication of the complexity of the problems which modern scientific medicine attacks.

This substance œstrin is also chemically related to another group of substances which play a very important part in the machinery of the human body. It is related to the chemical group which includes Vitamin D, which is in turn closely connected with other substances occurring in the body. There is no need at the present day to describe what the vitamins are. Everyone must by this time be aware of the important part played by these strange chemical substances, without which a normal human body cannot develop and cannot continue in health. The hormones, or internal secretions, which we have just been describing, are elaborated inside the body, and by their interaction control most of the normal processes of the human organism. The vitamins do not apparently play any part in controlling the chemistry of the body, but unless they are present normal function is quite impossible.

INCREASING KNOWLEDGE OF VITAMINS

The vitamins, as everyone knows, have been given instead of names the letters of the alphabet. Vitamin

A is now known in pure form, and its proper functions are being carefully worked out. Vitamin B, on the other hand, has not yet been isolated chemically; but we do know that there are a number of conditions in which the administration of substances containing Vitamin B, usually in the form of Yeast or Yeast Extracts, does lead to the restoration of normal function, especially in the nerves and in the intestinal tract. Vitamin E has not yet been completely identified either as to its composition or its functions, but it plays some part in regulating fertility and has been used with success in treating certain cases of repeated abortion. Vitamin C has been shown to be a comparatively simple organic chemical occurring in large quantities in fruits such as the lemon.

It is one of the romances of modern chemical advancement that for a long time it was recognized that the taking of the juice of such fruits prevented the development of the disease known as Scurvy, which at one time was very prevalent and very dangerous. Scurvy has almost entirely disappeared from the civilized world, but it is a strange comment on the arrangements of our present civilization that cases of Scurvy still occur even in large cities. A serious case which occurred in an unemployed man in London during 1935 gave research workers an excellent opportunity to observe the exact amount of Vitamin C or ascorbic acid which the body needs. It has been shown that in health there is always a certain measurable amount of ascorbic acid excreted in the urine. In this case of Scurvy, which was fully investigated, it was found that this excretion did not take place, and even when the case was treated did not begin until the body had taken up a very large amount of the Vitamin C administered. From this well-studied case it appears that the body requires enough ascorbic acid in the diet to keep it saturated with this substance, and it is only then, and not till then, that it gets rid of the excess.

RICKETS PREVENTABLE

Vitamin D, which is familiar in the form of Cod-Liver Oil, has also been obtained, and can be prepared, in pure chemical form. Its presence in certain minimum quantities in the diet prevents the occurrence of Rickets, which at one time produced bone deformities in an enormous number of young children. The amount of Vitamin D that is required to prevent this occurrence is very small indeed, and need not be administered artificially in anything but very small amounts if a proper diet is being taken. Rickets was at one time considered to be caused by the overcrowding, insanitary surroundings, and lack of sunshine with which it was so often associated. This was undoubtedly the case, for in these conditions even the small amount needed was often absent from the diet, and the lack of sunshine aggravated the condition. The formation of natural vitamin D is related to the action of sunshine on the skin.

We have a sharp commentary on modern affairs when we read that at the present day in industrial areas where unemployment is widespread rickets still occurs among the children. The work that has been done on these two vitamins exemplifies better than any other the way in which medical science fights disease. With these two substances freely and cheaply available we know that there need never again be any cases of Scurvy or Rickets. Science has indeed conquered these diseases, but it has not overcome the other forces in the shape of bad economic distribution, which, by preventing the use of these precious chemical substances, leads to the continued existence of crippling diseases that should long ago have vanished.

DIET DEFICIENCY IS NATION-WIDE

This lack of the necessary amount of vitamins in the diet of a section of the population is only part of the greater problem of the adequate nutrition of our industrial population. There have always been a certain number of people who have maintained that a large portion of the working class of this and other countries are unable to obtain an adequate diet. In recent years the evidence on this point has been accumulating, and since the beginning of 1936 quite a number of important writers have declared that millions of the population are unable to purchase anything like the amount or the quality of food which science has shown to be necessary for health.

One of the most important of these statements—that of Sir John Orr—has declared that at least four and a half million people in this country are unable to obtain a diet which contains adequate amounts of the substances necessary for health. There appears to be no question that at least ten millions of our population do not receive a weekly dietary such as the British Medical Association experts have declared to be the minimum necessary for health. Sir John Orr concludes: " As income increases, disease and death rate decrease, children grow more quickly, adults' stature is greater, and general health and physique improves."

It is the aim of medical science to ensure that every person in the community receives a diet which will permit of the optimum rate of growth and the maintenance of perfect health. Until that has been achieved, at whatever economic cost, much of the work that is done and many of the discoveries that are made by research workers will fail to have the effect they might have in ridding us of disease.

CHAPTER VI

INDUSTRIAL DISEASE

THE types of disease which we have already described cannot be said to arise directly from man's own activities. The developmental errors and defects are largely outside man's power even to prevent, although there are a number which have been shown so clearly to be hereditary that the civilization of the future may restrict marriage in such a way as to prevent their perpetuation. In the case of the bacterial and parasitic diseases it is often the case that man's way of living and lack of forethought encourage the existence of the disease; but the actual cause of the disease is not man's action, but a definite form of life which enters his body from outside.

ACCIDENTS CAUSE MUCH INCAPACITY

There are, however, many conditions which arise from the way in which modern man lives and the various activities which he carries on. To begin with, there are a great number of what are known as accidents, which every year cause not only very many deaths, but a really enormous number of temporary and some permanent incapacities. Accidents, in the very meaning of the term, should be entirely unexpected and unforeseen, and in quite a large proportion of cases this is unquestionably true. We can distinguish, however, one or two classes of accidents which are definitely related to our mode of living, and for which science, to some extent at least, has been able to suggest methods of prevention.

In all industrial processes involving the use of heavy or rapidly moving machinery the operatives are involved in certain dangers. So long as industrial processes were entirely uncontrolled by any administrative authority, these dangers were regarded as inevitable, and those who suffered as a result of them as merely unlucky. During the development of the present-day industrial age, however, by legislation and by the existence of various rules and regulations, it has been found possible to introduce into industrial processes a very large number of safeguards. We now have in this country an elaborate and fairly successful machinery for the examination of factories and the provision of devices to prevent accidents. It is impossible to detail these, but everyone knows that rapidly moving machinery must be protected in one way or another so that the hands and clothing cannot be caught in it, and a great variety of other rules are laid down for the safeguard of the worker.

Despite these the number of industrial accidents shows no sign of decreasing. In 1934 there were recorded 136,858 casualties in industry and 785 deaths from industrial injuries. It is not only necessary that these should be lessened in numbers, but we also require a method of compensating those injured in industry. The present Workmen's Compensation Acts have long been criticized, and a study of what happens under them will convince everyone that they are quite inadequate to give the injured easily and rapidly the compensation to which they are entitled.

A DANGEROUS INDUSTRY

There is one great industry in which accidents are always occurring—that of coal-mining. When a very large mining disaster occurs and some hundreds are killed by one explosion everyone is forced to realize what a dangerous business the getting of coal under modern conditions still is. Few people realize, however, that not only is this danger always present, but that every day there are deaths and injuries to many miners. The prevention of these accidents is, of course, a very special problem, but the solutions are fairly well recognized. If they were universally applied in the shape of better lighting at the actual coal face and better methods of building up the walls of the mine, with the provision of better tracks for the underground railways, the number of these accidents would be greatly diminished. It is not enough, however, to recognize the solution of such problems as these, but we must have methods of enforcing the carrying out of the regulations which scientific workers have shown to be necessary.

In passing we may remark that there is one disease—miner's mystagmus—which comes under a different category, and it is still the subject of some controversy. It is closely related to coal mining, although the actual defect in the nervous tissue which gives rise to it is not very clear.

ROAD DEATHS A MODERN PROBLEM

There is one very large class of accident causing every year many thousands of fatalities, which is definitely caused by man's modern habit of living in crowded communities and using high-speed methods of transport. Road accidents are now recognized as one of the problems which civilization must solve. There is no place in a book of this kind to discuss the subject as a whole, but we would refer to one point of undoubted interest. It has been shown by investigation in a large number of cases that there are, not only among motorists but among the population as a whole, a certain number of people who are described as " accident prone "—that is to say, that for some reason, most likely a little slowness in the reaction time of the nervous system, they are more likely to be involved in an accident if an emergency arises.

In the past such people have been discovered, usually by a worried insurance company, only after they have had a number of accidents. These accidents may be very small; but it would obviously be much better to find these people before they have a chance to do any damage to themselves or others. Methods for doing this have now been worked out by scientists, and it is actually possible to carry out tests which will show whether a person is likely to be a good driver or not. Whether the method is applicable to the whole population or any large proportion of it remains to be seen, but at any rate, even in the case of what might appear to be inevitable, science is endeavouring to fight another cause of death and disablement.

CHEMICAL INDUSTRIES OFTEN DANGEROUS

Modern industry employs an ever-increasing number of chemical and mechanical processes. The briefest consideration of the chemicals employed in such industries as the manufacture of rubber, the preparation of paints both of the ordinary kind and of the cellulose type, the use of chemicals in the production of iron and steel, and the tremendous voltages of electricity that are sometimes involved, will suggest an almost infinite number of possibilities of disease and accident. This recognition is not new, for the Factory Acts, which we have already mentioned, have been in existence in one form or another for a hundred years.

For a long time now so many diseases connected with industry have been recognized that it has been suggested that there is a place for a special study of industrial medicine. The University of Birmingham has recently appointed a lecturer for this subject, and everywhere medical men are coming more and more in contact with disease arising among their patients in the course of their employment. There are at the present day about forty diseases which can be legally classified as industrial in origin. The tragic fact about these diseases is that none of them appears to have been anticipated at the beginning of the particular industrial process which causes them, but are recognized only after they have actually caused disease and in some cases death.

SILICOSIS

Perhaps the most prevalent and most discussed industrial disease is Silicosis. This disease is particularly dangerous to those who once contract it, for it increases the likelihood of pulmonary Tuberculosis, and may be fatal even without that added infection. It is due to the inhalation of small particles of Silica, which is the chief constituent of many rocks used for building and other industrial processes.

Silicosis is now controlled by a special medical board appointed by the Home Office, and during the years 1932–1934 this body certified 1444 cases of disablement and 435 deaths from the condition. The condition is now well recognized by the medical profession and fairly easily identified; but there are undoubtedly still many cases which do not become certified officially, so that the above figure is certainly not too high. Silica is a danger not only to those industries preparing and using stone, but also in the use of powdered flint in pottery and the use of sandstone for grinding metals. Silicosis may therefore occur in a great variety of industries, and there is only one method of prevention—namely, to ensure that silica does not get into the lungs. This is not an easy process, for so long as silica-containing substances are manipulated in a dry state there is a possibility of small particles being inhaled at every respiration.

Closely related to Silicosis, and causing a very similar and also recognizable condition, is Asbestosis, which is already controlled in the same way as Silicosis. This is, indeed, a disease of modern times, for it is only in quite recent years that cases have been recognized in any number.

Other substances may give rise to disease, the chief being lead. This is also fairly widely used, not only as the metal, but also in a probably more dangerous form as white lead in the making of paints and certain glazes for pottery. Lead poisoning affects different parts of the body, and is usually recognized from a particular effect it has on the red blood cells. The best way, and one which has been adopted in many cases, of preventing its occurrence, is to abolish the use of lead products where substitutes are available, but there are other safeguards as well.

SPECIAL DANGERS TO THE SKIN

Some of the dangers that lie in industrial processes take many years to develop. This is the case with cancers of the skin, which can be caused by the constant application of small quantities of certain chemicals. The commonest of these is a cancer produced by the use of mineral oils, particularly in spinning-mills, and therefore often spoken of as "Mule-Spinner's Cancer." The method of lubricating a particular type of machine causes a constant splashing of small quantities of the oil on to the clothes, and after a period of years—sometimes twenty or more—a cancer may develop where the oil has been deposited. It is almost certain that this effect is due not to the oil as a whole, but to one particular chemical occurring in the oil; and by substituting a vegetable lubrication from which this carcinogenic substance, as it is called, is absent, the danger can be removed.

It has also been found that workers who use aniline dyes slowly develop cancer of the bladder, which is apparently due also to some obscure chemical taken up from the colours employed. The same workers may, of course, suffer from the effects of the dyes on the skin.

THE SKIN OFTEN IN DANGER

The skin probably suffers more than any other tissue from the irritation of industrial chemicals. In a recent article a well-known specialist gave a list of over thirty different forms of "occupational dermatitis." Workers are exposed to at least forty chemicals which may cause trouble, chemicals ranging from soap and soda to those used in making high explosives and poison gas.

A recently noticed example of occupational dermatitis will illustrate the difficulties of foreseeing these dangers. It has long been known that if the flowers of certain pyrethrums are dried and powdered, or if an extract is made from them, the resulting preparations are very lethal to insects. Pyrethrum powders are therefore much used in insecticides both in the house and in the garden. It is estimated that about twenty thousand tons are used annually.

The source of supply was formerly Japan, but some years ago the industry was introduced into Kenya Colony. In Japan the flowers are picked for only a month or two: in Kenya the different climate permits a flowering season of ten months in the year. As a result the workers in Kenya are exposed to the action of the pyrethrum powder for a very long period, and in that case a severe dermatitis develops, and, occasionally, even more dangerous symptoms. The experience of Japan had never suggested this possibility, which results from the prolonged season in Kenya.

AGRICULTURE NOT FREE FROM DANGER

This story reminds us that agriculture, as well as the factory, has its occupational risks. There are a very large number of plants, including some used in every house for decoration, that may cause a dermatitis. The ordinary daffodil and many bulbs such as the tulip have been shown to cause a skin eruption in susceptible cases.

The milk-farmer also runs a risk of contracting such diseases as Undulant Fever, which occurs among cattle. The germ causing this disease is usually conveyed in milk, but may also infect human beings by direct contact. Fortunately it is seldom a fatal disease, but it is a long and debilitating one.

INDUSTRIAL SOLVENTS

One of the greatest developments of modern times is the use of cellulose acetate and various derivatives, both for the manufacture of articles of great variety and for the making of paints which when applied give a very hard and glossy surface. Before it can be used, cellulose must be dissolved in some form of solvent, and a great variety of chemicals have been used for this purpose. Cellulose acetate has been much used for the varnishing of aeroplane wings, and among workers so employed many cases of poisoning occurred. It was not the cellulose but the solvent which, getting into the blood-stream, seriously damaged the liver. Solvents of various types are an essential part of many modern processes, and over a period of years quite a number of them have been shown to be dangerous to those using them. To such an extent is this recognized that there is a movement on foot to see that no industrial solvent will be used until it has been carefully studied from the point of view of whether or not it is likely to cause disease.

NEW DANGERS MUST BE ANTICIPATED

This is the point which will strike all those who are interested in seeing that science really does defeat death. Up to the present we appear always to have waited until cases of disease from these industrial processes occurred before taking any action. Even now it takes months and sometimes years before a hazard arising in industry can be legally recognized for purposes of Workmen's Compensation. The progress of industry will involve the use of many more new and possibly dangerous chemicals. It should be laid down that no manufacturer is to be allowed to introduce into everyday productive processes substances which have not been tested in such a way that at any rate the immediate danger will be recognized. There will be some which, like the slowly acting cancer-producing oils, will take years to produce the condition which will finally lead to their condemnation. If, however, the risks were reduced to those, and we abolished the others which produce death or disease in a short time, then we should have done something to make industrial methods safe.

Dr. Howard E. Collier, in a recent lecture at Birmingham University, advocated a special service of industrial physicians and factory surgeons with facilities for studying both industrial diseases and industrial processes. Such a service, he claimed, would safeguard the worker, provide early diagnosis, supply correct treatment, and enable correct assessment to be made in claims for compensation.

More than this, he considered it would provide research and investigation that would help industry by forecasting the " probable health effects of new substances or new methods." It would not only assist in accident prevention and facilitate early recovery, but would also make possible " the prevention of special occupational diseases and control epidemic and general disease." Until such a service is in full operation we are in no way dealing adequately with the problem of industrial health hazards.

RHEUMATISM AND INDUSTRY

Before leaving the subject of industrial disease we might ask whether a service for industry, such as we have just discussed, might not help us generally in solving the problem of rheumatic disease. Chronic rheumatic joint disease probably deserves a special service to itself, as does tuberculosis, but its effect on industry is so great that it might well be approached as if it were an industrial disease.

It is said that rheumatism in its various forms produces more pensionable invalidism than any other condition in those engaged in industry. It is probably true " that rheumatic diseases account for onesixth of the industrial invalidity of Great Britain." The annual cost is enormous, £20,000,000 for treatment being a quite conservative estimate. Rheumatic joint disease is caused by a combination of factors, of which the most important is the presence somewhere in the body—the tonsils, teeth, or appendix, for example—of a focus in which certain germs exist and by their poisoning effect on the whole body gradually produce the dreadful crippling process with which we are all familiar. Treatment must be early, and a great variety of methods may be needed to bring about a cure.

It is for this reason that rheumatism must be attacked on a national scale and by special machinery. Each case requires full examination and investigation by X-Ray and laboratory methods. Treatment may employ injections of vaccines or of gold, massage and manipulation of the joints, improvement of the general health by diet and convalescence, special baths or application of heat, light, or electricity, and even operations. It is obvious that science can do nothing even by the most brilliant research unless it is supported by a scheme which will make all these things available in every part of the country. Industry is already paying heavily enough for the rheumatic diseases; it must devise methods of prevention and early treatment which will in the end save the enormous sum at present spent on the condition.

CHAPTER VII

CANCER

We now come to discuss a problem of an entirely different type from any that has been described in the previous chapters—namely, that of cancer. There can be no one at the present day who is ignorant of what cancer means, for there has been incessant propaganda in the last few years pointing out the necessity for those who may be suffering from this dreadful disease to seek medical advice at the first possible moment. In the bacterial and industrial diseases which we have already described science has been able to show that some agent from outside the body causes the disease, and that by attacking or getting rid of that agent the disease can be prevented or cured.

CANCER CELLS ARE PART OF THE BODY

In the case of cancer, however, we are dealing with something which not only appears to begin within the body, but is in fact part of the body itself. Doctors distinguish a large number of different malignant growths, but to the lay public they are all alike, and are spoken of by the general term of cancer. They have, indeed, one great similarity—namely, that they are composed of cells which we can recognize as belonging to one or other of the groups of cells that make up the body.

In speaking of developmental defects in an earlier chapter we might have mentioned that sometimes it has been possible to show that small groups of cells of one type get misplaced in the course of development of the body and come to lie in an entirely wrong place. Occasionally these misplaced cells develop into quite normal tissue, reproducing the structure and function of the gland which they represent. Sometimes these collections of cells lie quite dormant for many years, but under some stimulus or another may begin to grow and form a recognizable tumour at a later stage in life. So far as that description goes we are apparently dealing with a quite simple process of misplacement of cells which, if they do grow, behave quite normally. It would, however, be an entirely different story if these groups of cells not only grew and functioned in a normal fashion, but also developed the power of growing more rapidly than the rest of the body, so that they spread into the tissues and throughout the body as a whole.

RAPID GROWTH OF CANCER CELLS

It is something like this that happens in every cancer. It has been suggested, and in a few particular instances it appears to be the case, that small groups of embryonic cells do take on this cancerous habit. On the whole, however, most cancers arise in tissue which, so far as its place in the body is concerned, is normal. Instead of functioning and growing at the normal rate, these cells begin to grow with great rapidity, and if they are in a position where the process can be seen, such as the skin, they eat into the surrounding tissue in the way that gives the disease its name. More than that, however, these rapidly growing cancer cells are able to spread into other parts of the body. The first thing they do is to grow into the lymphatic vessels and glands, which normally carry fluid from the tissues back into the blood-stream, and they may spread into all the other organs. Some parts, such as the liver, are particularly prone to these secondary growths.

A GROWING CANCER AFFECTS THE WHOLE BODY

Once such a rapidly growing cancer is established, it begins to affect the whole body. These malignant cells are, of course, utilizing foodstuffs at a very rapid rate, so that the rest of the body begins to lack supplies. They also destroy the normal tissues which

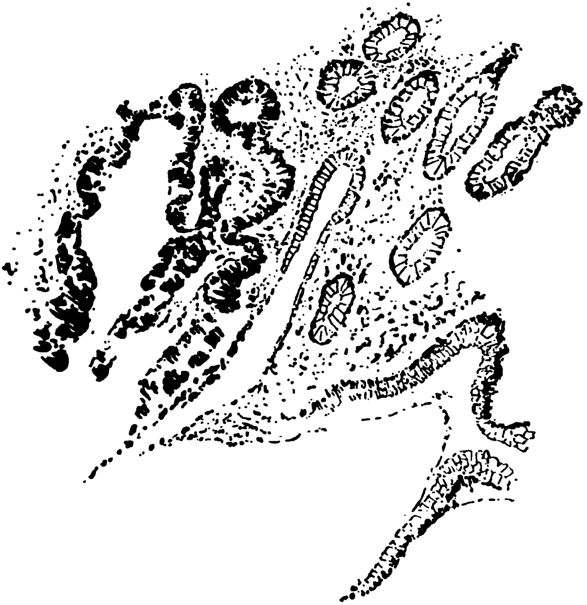

FIG. 11.—A MICROSCOPIC SECTION THROUGH THE EDGE OF A CANCER.

On the right are the normal regularly arranged gland cells; on the left the cancer cells are growing in irregular masses.

they invade, and very often they get into organs and situations which are of vital importance. Their presence there may be fatal, or may set up other diseases from which the patient may die.

In the case of cancer, therefore, we are dealing with the strange phenomenon in which the cells of one part of the body apparently attack the rest. The other cells put up some resistance, and some cancers grow very slowly indeed because of this; but on the whole the other tissues are powerless against the malignant cells.

OPERATION MUST BE EARLY

Medical science has long recognized that the most important way of dealing with cancerous growths is to remove them surgically. It has been quite clearly shown that, if the first group of cells which have become malignant are removed by a surgical operation before they have begun to invade the tissues, the chances are that the disease will be eradicated completely. The greatest difficulty in this direction is that advice is often not sought until the invasion of distant tissues has begun. It is estimated that, among those who are operated upon while the tumour is strictly localized, about eighty-five per cent. can be described as cured after five years. There are always cases in which even comparatively small primary growth has already spread to distant parts; but on the whole it can be claimed that by surgical removal at a sufficiently early stage the disease can be got rid of.

X-RAYS AND RADIUM

In addition to the ordinary methods of surgery much use in treating cancer has been made of radium, and, in more recent years, of X-Rays. It has been found that the rays given off by radium have a definitely lethal effect on cancerous cells. This is a field in which an enormous amount of research work is being done; for to obtain a success the radium must be so placed that the rays will penetrate to every cancerous cell. This requires a very specialized surgical technique, but many good results are obtained even in cases where ordinary surgical procedures are out of the question.

WHAT IS THE CAUSE OF CANCER?

It is usually suggested that we shall find a method of curing cancer long before we discover the cause. The success of some of the methods that have been tried seems to bear this out, but science cannot be content until it has found a method of preventing this dreadful disease from starting. To do so the cause must be discovered. The real cause, as we have already described, is this taking on of invasive properties by cells which correspond exactly to those in the normal body. What is required, however, is information as to the agents or substances which cause these cells to take on this property. Very slowly science has been accumulating information on this point; but it is still true to say that there is nothing like agreement as to whether there is one, and only one, exciting agent, nor as to whether it is an agent which enters the body from outside.

There are many cases of people who die from cancer which has remained fairly localized, but which has produced a general weakening of such rapidity as to suggest that there was another poisoning agent spreading throughout the system. On the other hand, there are equally numerous cases in which a comparatively small tumour has given rise to an enormous number of secondary growths in almost every organ. It may be that the difference in these cases is not so much in the exciting agent or in the cancer itself as in the resistance of the body as a whole.

IS THERE A CANCER VIRUS?

Numerous theories have been put forward as to what the exciting agent can be, and most of them have had to be discarded. There are two ideas which gain considerable support. On the one hand there are those who consider that the exciting agent must be of the nature of a virus. It is unquestionably true that there are a few tumours occurring in certain animals which can be passed through a filter, in the same way as the viruses which we have already described, and which will continue to excite the production of a malignant growth. So far, however, it has not been possible to repeat this observation with every type of cancer, and until that is done few will believe that a virus is invariably present in these growths.

CANCER ASSOCIATED WITH IRRITATION

From many facts that have been collected it appears quite definite that irritation in one way or another stimulates the activity of cancer cells. There are many malignant growths occurring in regions of the body where it is almost impossible to imagine what the irritation could be. There are others, however, in which not only can one postulate the irritation, but in which irritation in one way or another has been demonstrated. There is the case of those cancers of the skin which we have already mentioned as occurring in workers subject for years to the action of mineral oils, and there is also the well-recognized chimney-sweeps' cancer. We know also that cancer is particularly apt to happen in parts of the body which have been subjected to damage, such as the womb, which may be damaged in childbirth. There are also cancers definitely associated with chemical substances, such as those occurring in aniline dye workers, and there are cases following parasitic disease.

It will be seen that "irritation" is not the same in all these cases, and up to the present we have used this word only as a conception of something that upsets the normal function of the body cells. The idea arises chiefly from a study of cancer of the skin in which diet, oil, and chemicals which we recognize as noxious play their part. There is the well-known case of the Kangri cancer, which occurs in Kashmir. The natives carry a bucket of burning charcoal under their clothing to keep warm in the mountains, and a cancer develops in these parts of the skin with which the Kangri, as it is called, comes in contact.

It may be mentioned that something similar occurs in cancer of the tongue, which is ten times more common in men than in women, and which is in a number of cases quite definitely associated with pipe smoking.

EXPERIMENTAL CANCER

In the case of experimental cancer produced in animals it has been possible to isolate pure chemical substances from tar which, when applied to the skin, almost invariably give rise to a malignant growth. So far this is one of the best supported pieces of evidence in this amazing problem, and definitely suggests that irritation by chemical or other agents plays at least a part in the production of the malignant growths. It may be that we shall discover that a combination of these factors is necessary to produce the final picture. It may be, however, that we await some entirely new conception of this disease, which is so vastly different from all other diseases to which the human body is liable.

There are without doubt many people who worry about the prospect of developing a cancer, and this is not surprising when we recall that over 50,000 people die of the disease in England and Wales every year. Cancer attacks chiefly those over middle-age, and one in every seven deaths in persons over thirty is due to this condition. It is therefore often asked if cancer is hereditary, if it is infectious, or if it is due to any particular mode of life.

Attempts have been made all over the world to collect statistics that would settle these points, and the answers are in the negative. There is no evidence that cancer or the tendency to cancer is hereditary. Everyone knows of families in which succeeding generations have died from cancer, but the mass of statistics fails to show this to be anything more than coincidence.

So with the question of contagion, there are occasionally cases of cancer in members of the same family, but the statistical evidence is all against the possibility of cancer passing from one person to another.

IS CANCER A DISEASE OF CIVILIZATION?

Large-scale geographical surveys of races living under primitive conditions have been undertaken to ascertain whether cancer is more or less common among the uncivilized races than among the civilized. Figures are obtained with great difficulty, and allowance has to be made for such factors as the much greater " expectation of life " among the civilized. That is to say that more people reach the cancer age in civilized communities than among the primitive.

On the whole there appears to be no evidence that civilization causes an increased amount of cancer among the healthy. So long as the amenities of civilization are combined with proper regard for and use of the body, and so long as the special predisposing irritative factors we have mentioned are avoided, cancer does not seem to be any more prevalent.

DIET NOT A CAUSE

It is often asserted that particular forms of diet—*e.g.* the use of fresh meat or certain methods of cooking such as the boiling of vegetables—give rise to cancer. Statistical surveys of different races and also of different sections of our own population do not support this theory. Similarly no scientific evidence has been produced to show that an existing cancer is in any way affected by a particular form of diet.

THE PUBLIC MUST HELP SCIENCE

So far as our present knowledge goes, the public itself can help in many ways. It must always be remembered that cancer is very largely a disease of those over middle life, and for this reason it cannot be too often stressed that every symptom occurring in people over that age should be properly investigated at the earliest possible moment. There is too great a tendency at the present day for people to treat what they regard as minor troubles by means of patent and proprietary remedies, which may for the time being relieve the symptoms, but which leave the cause entirely untouched.

If all of these minor troubles could be investigated by all the methods of modern science there is no question that many cancers would be discovered at a stage when the surgeon's knife would ensure complete removal. The public must get rid of its fear of these operations, for modern surgery is able to carry out with amazing safety the removal of growths from almost every part of the body. In this way we have some hope of reducing by a considerable proportion the deaths which are due to cancer, and we shall also be providing opportunities for the study of what still remains a baffling mystery in the fight against death.

CHAPTER VIII

BLOOD DISEASES

It is seldom realized by those who have not studied the question that blood, as it flows in the vessels throughout the body, consists of two distinct parts. The first part is fluid and contains various substances required by the tissues mixed with the waste products of the body in a watery basis. This fluid is purely a vehicle for carrying all the necessary elements to the tissues, and it carries with it the second part, which is in fact a tissue like all the other tissues of the body. That is to say, it consists of cells specialized for the carrying out of certain duties in the metabolism of the body as a whole. When we speak of the blood in this chapter, it is with those tissue elements that we are concerned; for the fluid part of the blood-stream cannot of itself suffer from disease, although its chemical composition reflects many of the pathological changes in the blood.

TWO KINDS OF BLOOD-CELLS

The blood-cells are of more than one kind, being divided into the two familiar classes of red and white

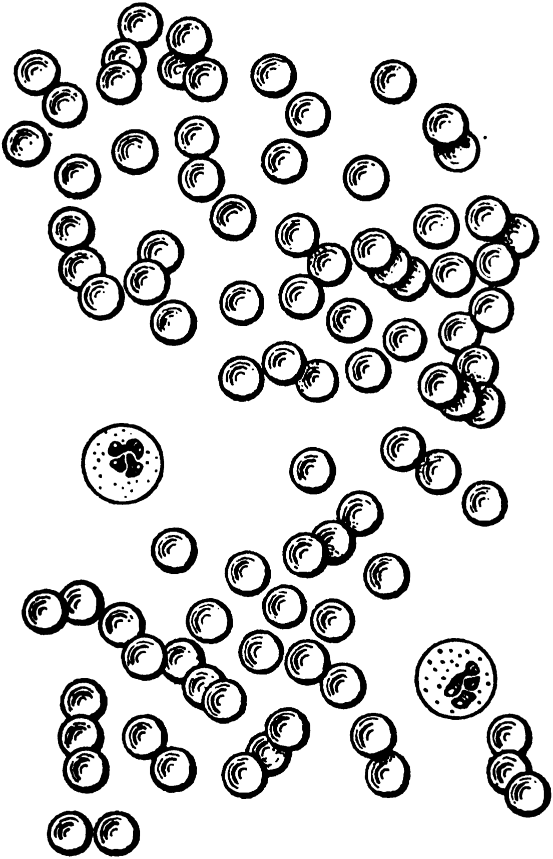

FIG. 12.—NORMAL BLOOD, SHOWING TWO WHITE CELLS AND MANY RED CELLS.

corpuscles. The red corpuscles are present in by far the greater number, as shown in Fig. 12, but we shall discuss the white cells first.

The white cells are not all of the one kind, and from the changes that take place in their number during the course of various diseases it appears that the different types have slightly different functions. The total number of white cells and of each type remains, as with so many other things in the human body, at a constant level while health is maintained. In the diseased body, however, these numbers may be altered either upwards or downwards. In this chapter we are concerned mainly with those diseases that occur in the blood as a tissue, but it is as well first of all to look at the changes that occur in it when other tissues are diseased.

WHITE CELLS MAY INCREASE IN NUMBERS

The most important change, and by far the most common, is that which occurs when there is an acute inflammatory process going on in some part of the body. Supposing, for example, a patient is suffering from an inflammatory condition such as Appendicitis or Pneumonia, or an abscess in any part of the body. In such a case the total number of white cells per unit of blood can be counted, and will be found to range from twice normal to as much as ten times normal,

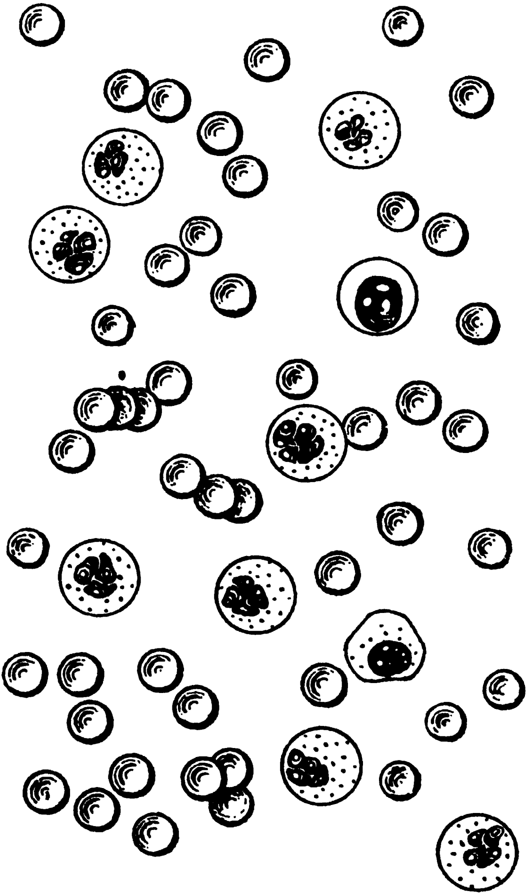

FIG. 13.—BLOOD SHOWING LARGE NUMBERS OF POLYMORPHONUCLEAR WHITE CELLS IN AN INFLAMMATORY DISEASE (cf. Fig. 12.)

according to the type of inflammation that is present. In obscure febrile illnesses this is sometimes a very valuable diagnostic point, indicating as it does the extent of the inflammatory process.

The reason for this increase in the white cells is that one class, known as the Polymorphonuclear neutrophiles, has the function of destroying disease germs that have entered the body. They appear in very large numbers because they are poured into the blood-stream by the bone marrow, which is the place where new white cells are manufactured, and proceed to the area invaded by the germs. An abscess is in fact a collection of these cells together with the

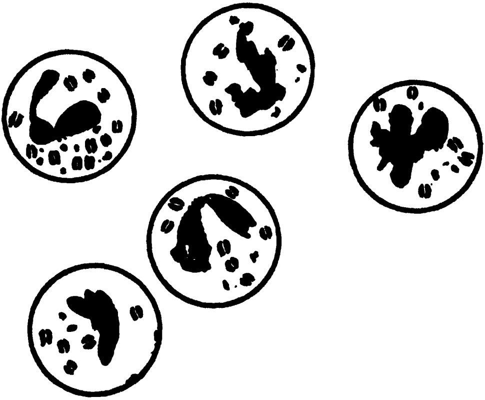

FIG. 14.—PHAGOCYTOSIS.

The white cells have absorbed many disease germs (in this case Gonococci).

germs which they have attacked and destroyed. In certain cases it is possible to demonstrate distinctly, as in Fig. 14, how the white cells engulf and destroy bacteria. In the process, of course, many white cells are themselves destroyed, and the bone marrow sends new ones into the blood-stream to make up for this.

There are certain conditions in which the increase in white cells may be chiefly of the second large group, known as the Lymphocytes. This is a type of change which may occur in tuberculous lesions, and also to a very marked degree in one or two virus infections. Another type of cell which is similar in appearance to the polymorphonuclears, but is distinguishable by its behaviour when stained with certain dyes, appears in the blood in increased numbers in parasitic infections. It is for these reasons that the carrying out of the differential count of the white blood cells is an important point in differentiating diseases.

DISEASES IN WHICH THE WHITE CELLS DECREASE

The white cells may also suffer a decrease, and in such an infection as Typhoid Fever this is the case. Since the blood-cells are like all other tissue cells they are subject to damage from poisons getting into the blood-stream, and certain bacterial and other poisons may destroy large numbers and even prevent their formation. In recent years much has been written about conditions in which the bone marrow is apparently so badly damaged by certain poisons that it is no longer able to manufacture new cells of the polymorphonuclear type, and these may practically disappear from the blood-stream. This condition goes by the name of Agranulocytosis, and it has been shown that, while it is not the only poison, a chemical called Amidopyrine is the chief cause of this complaint. It is worth emphasizing this matter, for Amidopyrine is a drug which in the past few years has had extensive use because of its power as a pain-killer. Its effect on the white cells in susceptible cases is, however, so damaging that the drug has now been brought under the control of the Poisons Acts.

This destruction of the white cells leaves a patient open to the attacks of all disease germs with which the polymorphonuclears usually deal, and in cases of this disease the patients usually succumb to a severe infection. This is the type of problem which science has had to tackle over and over again in the history of medicine, and, once the condition has been recognized, chemists set to work to find an antidote to the poison. A substance has been found which has been very beneficial in a number of cases because it has the power of stimulating the bone marrow to produce white cells in large numbers. It does not act in every case;

but, if this disease continues to exist even when the use of Amidopyrine is properly controlled, with the knowledge already gained it should be possible to discover a substance of more certain action on the bone marrow.

PRIMARY DISEASE OF THE WHITE CELLS

Apart from these changes in the white cells, which are really secondary in nature, there are conditions in which changes take place in the blood-cells that must be regarded as a disease primarily of that tissue. There are two types of this disease, but the general picture of both is the same—namely, the presence in the blood-stream of white cells in enormous numbers. Not only are the cells increased to such a figure as fifty times normal, but there appear in the blood large numbers of abnormal white cells. The white cell, it should be explained, develops in the bone marrow from a much more primitive type of cell, and this development is quite a lengthy process. In the presence of this disease, known as Leukæmia, so rapidly are the white cells poured into the blood-stream that all stages of development may be represented.

It has been suggested that Leukæmia represents the same process taking place in the blood-cells as cancer in other tissues. The cells grow at a more rapid rate, become primitive in type, and spread throughout the

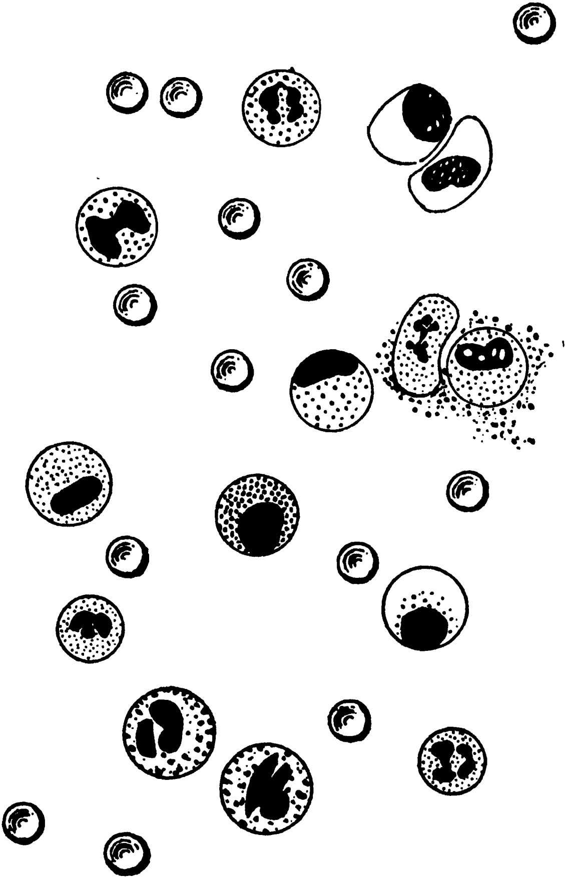

FIG. 15.—THE BLOOD IN LEUKÆMIA SHOWING THE GREAT INCREASE IN WHITE CELLS, MANY ABNORMAL IN TYPE (cf. Fig. 12).

body. So far no cause for this condition has been found, and, although in recent years the use of X-Rays has been found to alleviate the condition and prolong life, it is usually fatal.

In stating above that the fluid part of the blood-stream was not subject to disease we should have mentioned that it may, however, provide a place for the growth and multiplication of parasitic invaders of the body. We have already mentioned Malaria, which goes through one part of its life-cycle in the red blood-cells, but which also exists at times floating freely in the blood-stream. There are a number of other parasites which live and multiply in the blood-stream ; of these the filariæ, found in tropical countries, are among the most important.

THE RED CELLS ARE A SEPARATE TISSUE

The red blood-cells are so entirely different from the white corpuscles that they may be considered as an entirely separate tissue. They have the most important function of carrying oxygen from the lungs to all the tissues of the body and of returning with carbon dioxide, which is a waste product of the tissue metabolism. They do this by virtue of their content of that marvellous substance hæmoglobin, which can take up oxygen from the air in the lungs with great rapidity and hand it on to the cells in remote parts of the body with equal facility. Once again we have to remark that this element of the blood remains constant in amount during normal life.

The red cells (Fig. 16) are small, disc-like objects, and there are millions upon millions of them in the human circulation. They differ from all other cells in the body in that they have no nucleus, but nevertheless they are composed of living protoplasm and their life is limited. Like the white cells, they are manufactured in the bone marrow, and the bodies of those that die are dealt with by the spleen and the liver.

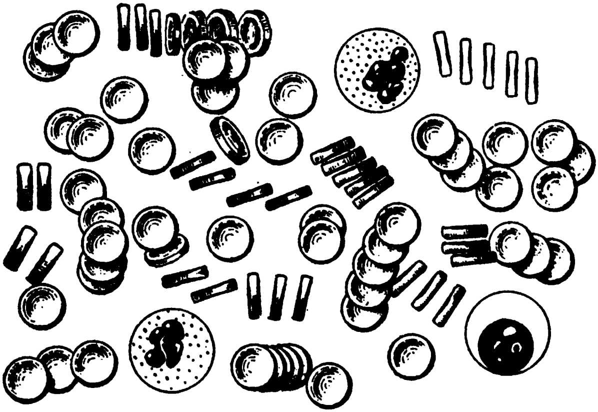

FIG. 16.—NORMAL BLOOD. (For comparison with Fig. 17.)

RED CELLS EASILY DAMAGED

The red cells are just as subject to detrimental influences as are the other tissues. In practically all diseases, but particularly in those caused by a germ which produces a circulating toxin, the red cells both in the blood-stream and in their primitive forms in the bone marrow are likely to be damaged. If this occurs, there is a diminution in the number of red cells in the blood, and the patient becomes anæmic. Not only may the number of cells become less, however, but each cell may contain less than its normal amount of hæmoglobin. When these changes occur as the result of disease, it is said that we have a secondary anæmia, and this can usually be cured by the removal of the disease process and the giving to the patient of amounts of iron large enough to make up for the destruction of hæmoglobin.

The red cells may also suffer from diseases which affect them primarily. There are one or two rather strange and somewhat rare conditions of this type. There is, for example, the " sickle cell anæmia," in which the normal disc shape of the red cells is entirely lost and all kinds of abnormal shapes occur, the chief one being that of a sickle. This strange disease is apparently confined to negroes. There is in this and in all other countries, however, another disease which is familiar, in which the red cells tend to be more spherical than normal and are also much more fragile and liable to be broken down by noxious influences. Acholuric jaundice, as it is called, is treated successfully by removal of the spleen.

PERNICIOUS ANÆMIA AND ITS TREATMENT

The chief primary disease of the red cells is, however, Pernicious Anæmia, which at one time was an invariably fatal condition. It is not particularly common, causing the death of a few hundred people each year in this country ; but it has been recognized for eighty years, and because of its unusual features has always attracted much medical attention.

In pernicious anæmia there is a steady decrease in the number of red cells, the patient slowly losing strength as the process goes on. The effects are very like those of any severe anæmia, but the blood-cells are found to show very different changes from those in the simple anæmia due to disease, which we have just described. In that condition the cells tend to be small and to have less hæmoglobin than usual. In pernicious anæmia, on the other hand, the cells are on the average larger than normal and contain as much or more hæmoglobin.

A serious case of pernicious anæmia presents a picture which is easily recognized. It usually occurs in people over middle age and is very often associated with or at least accompanied by very pronounced dental sepsis. It begins very slowly so that the patient at first is not alarmed, but as the blood becomes more and more impoverished a stage is reached at which the victim is no longer able to force himself even to walk. He looks exceedingly pale with an easily recognized yellow tint and very often complains of a sore tongue.

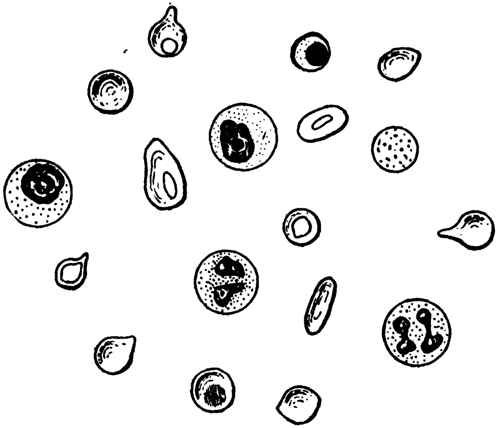

FIG. 17.—PERNICIOUS ANÆMIA.

The same volume of blood as in Fig. 16 showing the small number and abnormal types of red cells.

STRANGE BLOOD CHANGES

If the blood is examined at this stage the microscope reveals very serious changes in the red cells, such as are shown in Fig. 17. The cells are of all shapes and all sizes, and many of them show a nucleus, which, as we have already mentioned, is never possessed by a normal red cell. Although the red cells look all shapes and sizes, it is found by accurately measuring some hundreds of them that the average diameter is much above normal. This feature is the most important point in the microscopic diagnosis of pernicious anæmia.

This condition of the red blood-cells is not due to a lack of hæmoglobin, but to the inability of the bone marrow to produce new red cells. The disease is one which usually shows natural remissions and this made the working out of the correct treatment very difficult. Many things were tried, but if their use coincided with a remission it was thought that the improvement was due to the medicine given. It was only after a time that all the methods tried were proved to be of no avail.

A MEDICAL TRIUMPH

In the last few years pernicious anæmia has provided medicine with one of its greatest triumphs, for a method has been discovered of treating this disease with great success. The discovery was the result of an investigation into the fundamental changes that take place in anæmia, and has been followed up by an immense amount of work. It now appears that the normal production of red cells is another part of the human mechanism which depends on a delicately adjusted balance between substances present in the food we eat and substances stored by one of the glands of the body—namely, the liver. So long as both these factors are present we go on manufacturing normal numbers of normal red cells. In the pernicious anæmia patient the factor elaborated and stored by the liver, and to some extent by glands in the wall of the stomach, is lacking. The discovery that has meant so much to sufferers from this disease is that this liver factor can be extracted and can be adminstered either by mouth or by injections. At first the extracts made were crude and their action uncertain, but now there are a large number of extracts available of great purity and very high potency.

TESTING THE LIVER EXTRACTS

We are still faced with one difficulty, even with the best of liver extracts—namely, that there is no method by which the potency can be tested except on a patient suffering from the disease. When a potent extract is injected into such a patient, whose blood may contain as little as twenty per cent. of the normal number of red cells, the change that takes place is little short of amazing. In order to follow what happens, a method is used of staining the blood which distinguishes the newly formed red cells from those that have been in the blood-stream for some time. These cells, illustrated in Fig. 18, are called Reticulocytes from the way in which they stain by this method. The patient whose blood contains practically none of these cells at the beginning of the course will after a few injections show as much as forty per cent. of new red corpuscles. These rapidly become normal in size and shape, and therefore remain in the blood-stream for a longer period, and in a few weeks a patient's blood once more contains its normal quota of red cells.

We cannot, however, claim that this administration of liver extract constitutes a cure. It does restore a patient's blood to a normal level, and with that restoration brings about an amazing improvement in the general condition; but it does not enable the patient to recommence the manufacture of the missing substance in his own body. His blood will remain normal only so long as he continues to take a certain amount of liver extract.

At one time this not only meant a considerable expense, but was not altogether a pleasant process; to-day, however, we have liver extracts which can be given by injection at such intervals as once in a few weeks or even months, and will maintain the blood at normal level. So long as sufficient liver extract is given there appears to be no danger of any relapse,

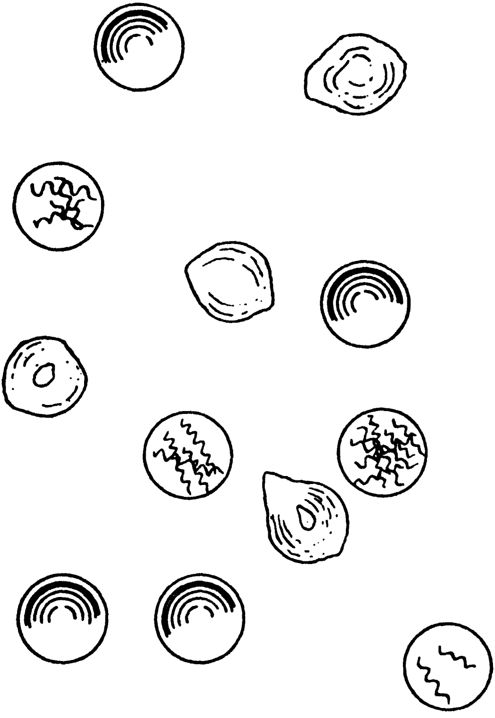

FIG. 18.—THE BLOOD IN THE EARLY TREATMENT OF PERNICIOUS ANÆMIA, SHOWING NEW RED CELLS (RETICULOCYTES).

and it is really amazing to see the way in which the blood responds to this even in the aged.

REPEATED BLOOD EXAMINATIONS NEEDED

The story of pernicious anæmia is one of careful and painstaking investigation coupled with a close consideration of the clinical condition of patients suffering from this disease, and represents what can be managed by properly controlled medical research. The same disease provides us, however, with an example of how difficult it is to translate scientific discoveries into accepted methods of treating disease, especially where official bodies are concerned. Cases of pernicious anæmia occurring among that section of the population which comes under the National Health Insurance can be treated by their doctor with liver extracts. The control of such cases, as we have indicated, can be managed only by examination of the blood, and the only reliable method of finding the dose of liver extract which will maintain the blood at a normal figure is by repeated examinations of each case. The National Health Insurance machinery, which enables treatment of pernicious anæmia to be given, does not, however, permit of examinations of the blood to be done in those who cannot afford to pay for them themselves. In other words, a scientific discovery which has been placed on an absolutely sound foundation and which is recognized throughout the world cannot be used to its fullest because the regulations laid down in an Act of Parliament many years ago do not permit it.

THE BLOOD MUST HAVE IRON

In concluding this chapter we must return to a point which relates more to the normal functioning of the body than to disease. We have already mentioned that new red cells are constantly being manufactured by the bone marrow, and there is therefore needed a constant supply of iron for the manufacture of hæmoglobin. Most of that substance present in old red cells is saved by the liver and spleen, but a certain amount is lost, and must be replaced.

Iron is present in most diets, but a minimum amount must be available to maintain the normal hæmoglobin level. It has been found that a " nutritional " anæmia may occur not only in young babies, but also in adults. Investigations have shown that this is particularly common among working-class mothers, especially those who have many children, and that it can be prevented and cured by giving iron by mouth. This is the type of comment on our present economic arrangements which science is being forced to make more and more often. It is no exaggeration to say that it is their economic condition alone which denies to these cases a normal blood supply, without which even the healthiest body cannot maintain its condition.

CHAPTER IX

SCIENCE MUST PREVENT DISEASE

WE have tried so far not only to give a brief summary of the problems that face medical science in the fight against disease, but also to suggest a way in which many individual problems must be tackled. There remains, however, the main question of how ill-health in general is to be prevented. It is now fairly well recognized that health must mean more than the mere absence of disease. The truly healthy person is one who is not only free from disease, but who is also able to enjoy life to the full and to carry out with vigour all that is required of him in the environment in which he finds himself. To preserve that health, the individual must play his or her part; but, because the environment is of such immense importance, the protection of health becomes one of the primary duties of the State.

IMPORTANCE OF ENVIRONMENT

To some extent this has been realized in most civilized countries for a long time, and we are all familiar with the efforts that have been made to devise a proper sanitary system. So far as most large cities are concerned, it is probably true that an adequate system of sanitation is provided; but there are still other environmental problems which require to be solved. The most important of these is unquestionably that of housing, and no government in any country has approached this problem in the way that a proper regard for the health of the individual citizen would dictate. Health of the kind we have suggested as the ideal is quite impossible for a very large proportion of town-dwellers, who are compelled to live in overcrowded and in many ways insanitary and unclean houses. If the individual is to have the type of environment which will give him a real chance of maintaining health the housing problems must be so solved that everyone will have a house and sufficient accommodation, and in the type of surroundings which have long been recognized as the minimum that can be permitted.

This problem might be tackled with more vigour if it was realized to what an extent it really is a health problem. The State has not hesitated to interfere in other matters concerning health. Over a period of a hundred years a large number of laws have been passed in this and other countries laying down rules and regulations designed to prevent disease. The whole of our sanitary laws have this in view, and so also have many of the Factory Acts and Public Health Acts.

A GREAT ADVANCE

We have already described the great advance in medical knowledge that was made with the discovery that bacteria caused disease. With regard to the preservation of health this also enabled a great step forward to be taken; for, with the realization that bacteria played such an important part, " the problem of hygiene in protecting man from infectious diseases was clearly outlined: to keep away the causes of disease from man, and if possible to destroy these factors." Part of this was done by the laws relating to cleanliness and sanitation which we have already mentioned. It was not long, however, before it was realized that infectious diseases pay no attention to frontiers, and, if plagues of one kind and another were to be prevented from spreading, hygiene must be international. It was this that led to the establishment of quarantine laws, which aimed at preventing those suffering from infectious diseases from entering a new district. The quarantine laws, however, involved a very long delay at ports and frontiers, and, as knowledge increased, they were replaced by other laws under which only those suffering from disease and those who had been so closely in contact with infectious cases that they might be incubating the disease were prevented from entering one country from another. That these laws have been effective must be obvious from the fact that diseases which at one time spread throughout most of the civilized world have very largely been confined to those areas where laws do not exist or cannot be adequately applied.

INTERNATIONAL CO-OPERATION NECESSARY

It is a very satisfactory state of affairs that the laws with regard to quarantine and the prevention of the spread of infectious diseases generally are standardized to a large extent throughout the world. Such agreement among nations was made possible only when the League of Nations set up a special section to deal with health problems. The Health Organization at Geneva cannot yet be said to have made more than a beginning in tackling international health problems; but, as the *British Medical Journal* recently pointed out, " what has indubitably been acquired is the habit of co-operation between medical men and women of different nations." The results of this habit are becoming more and more apparent every day. It is not merely that the statistics of different countries are becoming more standardized, but agreement is often possible with regard to methods of treatment and prevention to be adopted throughout the world. We have already mentioned, in discussing the treatment of infectious diseases by sera, that these are put on the market in a form which standardizes the dosage in all countries that have accepted the methods agreed upon by the Health Organization at Geneva.

RAPID TRAVEL A DANGER

The fight against disease is never stationary, and no sooner has any branch of medical science solved a problem than some change in the conditions under which most of us live to-day may involve a new and unforeseen danger. The quarantine of the Public Health Acts, as we have already mentioned, has very largely succeeded in preventing the spread, at least in this country, of certain of the most serious epidemic diseases. To some extent this has been aided by the time taken to communicate with those countries in which these diseases are always present. The aim of modern transport, however, is to make as short as possible the time taken by any journey, particularly by the use of the aeroplane. This introduces the danger that epidemic diseases may be carried with extraordinary rapidity from one place to another. It is not only that human beings may carry the disease, but there is also the possibility that some of the vectors we have mentioned may make the journey also while in an infected state. The fear has already been expressed that mosquitoes infected with malaria or yellow fever may travel in aeroplanes to regions where these diseases have previously been unknown. The danger may be slight, for the number of people who might be infected by one insect is small; but we cannot be absolutely certain that the infection might not find another intermediate host which would spread the disease. However, the problem has already been recognized, and a way of preventing trouble will certainly be found.

PREVENTION THE KEYNOTE OF THE FUTURE

Prevention must, of course, be the keynote of medical science of the future. This will take many forms, and not the least of these will be a greater use of preventative immunization. At the moment this can be applied with sufficient certainty and speed to only a small number of diseases. It is quite likely, however, that modification of the methods already in existence will prove effective for other diseases, and it is to be expected that we shall have in our hands methods that can be applied either for the protection of the individual who is likely to run the risk of infection, or, in the case of epidemic diseases, for that of the whole community.

EUGENICS MAY HELP

There is one field in which we have yet to see even the beginnings of what may at some future date be accepted as the recognized procedure. We have already mentioned those diseases and defects that arise in the development of the child or by inheritance. We know quite definitely that certain defects are passed on from generation to generation, following the genetic rules which have been worked out by innumerable experiments on animals and plants. Professor J. B. S. Haldane, in one of his articles, suggests that " Seven hundred years hence we may know enough of human genetics to say that the child of two particular parents will probably be a writer of the type of Mr. Aldous Huxley." Whether we shall ever reach that stage with regard to human beings, and whether we should ever try to apply it, are too problematic for discussion here. What may happen, however, is that by the application of eugenics we shall eliminate from the community certain mental and physical defects about the inheritance of which we have sufficient information.

It must be noted that these defects occur in all classes of society, and it must not be supposed that the working class are the poorer stock. Environmental factors are of such immense importance that it will only be when they have been eliminated that we shall be able to judge accurately to what extent eugenic methods can be used to produce a general improvement in the average citizen.

HEALTH PROPAGANDA

The application of eugenics would, of course, involve the co-operation of the lay public, and that co-operation implies a knowledge of the subject which is not at the moment very widespread. The same applies in most fields of hygiene, and, as this co-operation is of immense importance, steps are being taken in many directions to educate the general public on matters of health. Propaganda may be general, telling something of the story of health and disease and giving a few simple rules for the preservation of the former, or it may be particular, aiming at the abolition of habits considered to be wrong and the substitution of others more likely to preserve health. This propaganda must, however, be done with considerable care; for we must not run the danger of producing neurasthenics by making the fear of disease too vivid. Propaganda for the preservation of health must, of course, be one of the duties of local and governmental authorities, and in this country we have not yet seen the beginning of an effective method of educating the public.

A SPECIAL CASE

Propaganda may be the principal method of eliminating such conditions as the venereal diseases. Syphilis presents a very important problem; for not only does it cause a large amount of very varied and often fatal ill-health, but the germ can pass to the next generation with disastrous results, such as blindness. Here we have a disease of which we know the cause, have definite methods of diagnosing the condition, and efficient methods of treatment. Nevertheless the disease continues, and infects a surprisingly high proportion of the population. The difficulty is, of course, that it is a disease that is seldom openly admitted or discussed. Our usual methods of prevention break down, and we shall have to rely on propaganda to conquer it.

That propaganda must not only emphasize the dangerous nature of the disease, but must also make it clear that it is practically always contracted in the one way. Everyone must know also that if treatment on the correct lines is begun early enough not only will the condition be cured, but, most important of all, the patient will cease to be infective and can no longer pass the disease to others. Propaganda on these lines has been carried out, and this disease has had much attention from the authorities; venereal disease clinics now exist in most large cities.

HEALTH IS THE CONCERN OF THE STATE

The whole question of health should, of course, be a primary concern of any Government. The progress of any civilized community depends on the type of citizens it has, and it becomes increasingly clear not only that health is the ideal for the individual, but also that the State can continue to exist only if its citizens are able, by reason of their freedom from disease, to put into their common activities all the service of which they are capable.

If the medical profession is to play its proper part in this it will require to be organized by the State for that purpose. At the moment the medical profession exists almost entirely for the treatment of disease, and few doctors have the opportunity, or even the training, to carry out preventive work on the lines that would be laid down scientifically. If this is to be done a new form of medical organization in which all doctors are linked together in the one service is urgently required. It is required also in order that medical men may have ample leisure for study, so that they may keep abreast with all the developments that are taking place. This will become increasingly important; for the rate of discovery of new medical knowledge is apparently increasing every day. That rate of discovery can be even faster if we achieve a properly organized method of medical research—one that will not only enable doctors of this country to investigate the problems that are still unsolved, but also one which will increase and elaborate the international co-operation that at present exists.

That co-operation must be fostered to the full, and we must realize that it is not for the benefit of the medical and scientific professions alone, but for the whole community. It is not enough that we have effectively defeated disease in certain cases, but we must go on to the greater aim of preserving health. As Professor Henry Sigerist in his book *Man and Medicine* summarizes it: "We must not forget that hygiene and its goal, health, is not the end, but the means to an end. Health has a definite mental and physical attitude, which is to help us to work effectively for the benefit of our fellow men and to help to make our lives enjoyable."

In reaching that end science has the chief part to play. All branches of scientific study are closely linked together, and discoveries made in one field may lead to new ideas in another. This is particularly true of medical science, which has borrowed extensively from every field of scientific thought and discovery. The problem not yet completely solved is how the discoveries made by medicine by scientific methods are to be translated into health for all in a healthy social environment. As we approach nearer and nearer to that ideal we shall begin to have citizens who are more fit to put into operation the environmental improvements indicated and made possible by other sciences, and as these improvements are made we should have citizens better able to enjoy life, freed from the constant worry of disease and ill-health.

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